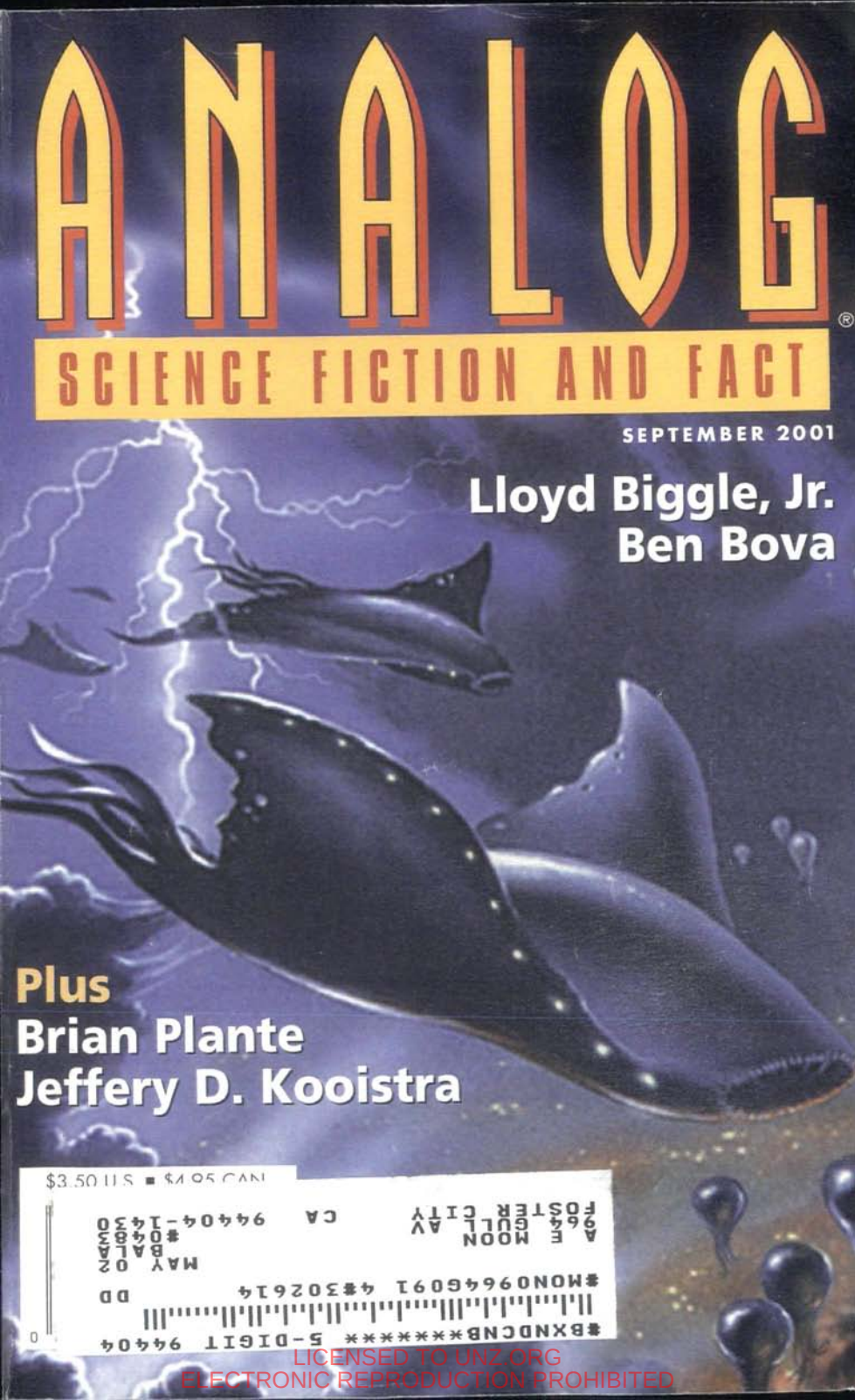

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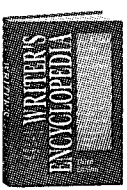

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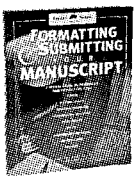

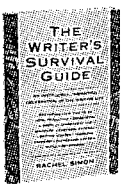

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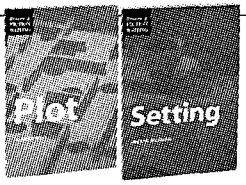

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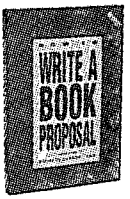

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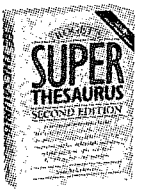

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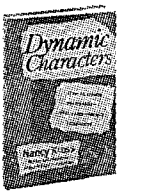

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ANALOG

SCIENCE FICTION AND FACT

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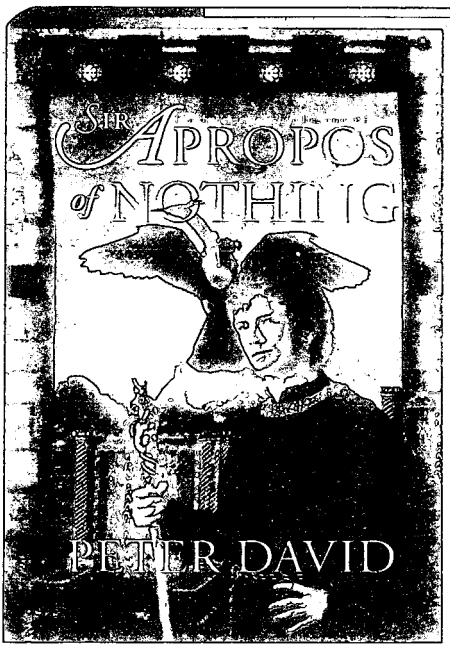
FROM THE *NEW YORK TIMES* BESTSELLING AUTHOR OF *IMZADI*

Chivalry is not dead

(mainly because he isn't through with it yet).



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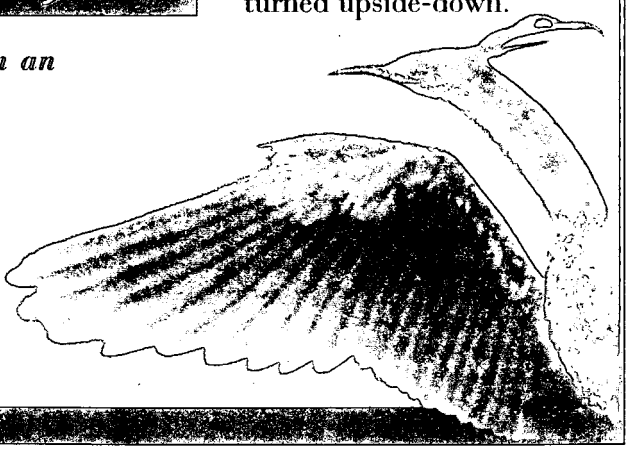

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TEMPORAL PROVINCIALISM

Some years ago *The New Yorker* magazine had a cover showing "a New Yorker's view of the world." Looking west from an upper story above the east side of Ninth Avenue, we see Ninth and Tenth Avenues, and the tall buildings lining them, filling most of the picture. Beyond those lie two strips running the full width of the scene: a wide one labeled "Hudson River" and a much narrower one labeled "Jersey." And beyond those lie three more rather narrow bands. The first shows Mexico at the left, Canada at the right, and Washington (D.C.), Texas, Los Angeles, Utah, Las Vegas, Nebraska, Kansas City, and Chicago strewn not quite randomly in between. Then there's the Pacific Ocean, and finally, like an afterthought on the not very distant horizon, China, Japan, and Russia.

It strikes most people as funny, if only for the sheer incongruity of the proportions. I suspect it amuses different people for different reasons, but for me (not being a native New Yorker) the funniest thing about that picture is that it seems to me that many New Yorkers really do see the world that way.

No, I am not making a blanket statement that all New Yorkers have such a distorted view of the world and their place in it. But a disproportionate number of them do. I have traveled widely and talked to people with a great range of backgrounds, and I have found an inordinately large percentage of New Yorkers who make it clear by word and/or deed that they regard practically everyone else as provincial. Ironically, these particular New Yorkers are themselves some of the most provincial people I've ever met, at least in the sense that the American Heritage Dictionary defines as, "Limited in perspective; narrow and self-centered." They really do seem to think that New York City is the center of the Universe, and that other places and their denizens and ways have little importance and little to contribute to the world at large.

I say all this not to malign or antagonize New Yorkers, or to vent my frustration at how they've mistreated me (they haven't), but merely as an interesting and amusing example of one particular kind of common human shortcoming. As Garrison Keillor demonstrates every week on "A Prairie Home Companion," you can find such foibles among any people, with different ones more or less common in different regions or populations. New York just happens to offer one of the more striking examples of a particular one: the tendency to regard one's own home turf as having more importance in the larger scheme of things than it actually does.

Another dramatic example of that kind of provincialism defines home turf not in terms of geography, but in terms of time. In "temporal provincialism," people believe that the preferences and standards of their own time period—their own "historical neighborhood"—are the only ones with any real value, and everything, including people and events of the past and future, should be

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judged by them. I'm not in a good position to judge whether our current period is more strongly afflicted with such temporal provincialism than most others, but it does seem to me quite rampant.

I've dealt with a couple of aspects of it in earlier editorials. "Do It *Our* Way!" (Mid-December 1985) pointed out the irony of science fiction readers (who, as a group, are unusually good at seeing and empathizing with different ways of thinking and doing) complaining about stories depicting future societies that didn't conform to standards generally accepted by our own. "Ex Post Facto Ethics" (October 1992) was an answer to the fad of condemning historical figures for violating moral principles widely accepted in our time but not their own. Today I'd like to look at a different aspect of temporal provincialism: the tendency to regard the art and literature of other times as irrelevant, though sometimes subject to redemption by artificially transplanting them to our own time.

Some aspects of this will surprise no one. We've probably always had people whose lives revolved largely around being continually "on the cutting edge," following the latest fads in music and clothing and sneering at anything that was fashionable in earlier years or decades as outmoded, obsolete, and irrelevant. (It seldom seems to occur to such people that the very fads they try so hard to follow will soon be relegated to that same status.)

Other aspects are more subtle. We've all noticed that moviemakers often feel compelled to remake old movies. Sometimes these stem at least in part from a desire to do things with a story that weren't possible with the technology available at the time of the original, like showing the lush South Pacific settings of *Mutiny on the Bounty* in wide-screen color instead of cramped black-and-white. Sometimes, though, we'll find a movie that was originally set and filmed, say, in 1950 being transplanted to, say, 2000, keeping the bare bones of the story line, but "updating" it by changing the settings, characters' jobs and costumes, mannerisms, slang, musical styles, and topical allusions to those of the later period. Sometimes we're told, implicitly or explicitly, that the point of all this is to make the story "relevant" to people of a new period.

What I find disturbing in all this is the implied assumption that only our present culture "counts," and others can earn our attention or empathy only if someone makes them look like ours. Why not go the other way and teach people to appreciate similarities despite differences—and even the differences themselves?

One of the things that first attracted me to science fiction—and its close relatives, historical fiction and fantasy—was that they were *not* about times and places just like ours. I reveled in the opportunity to see that there were many

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possible ways to live, and to see some of those ways "from inside," if only for the duration of a story. I enjoyed the mental exercise of trying to imagine myself living in a different time or place, seeing things as its people did.

Now, it seems, many people (sometimes even science fiction people) are unwilling or unable to bother. One of my direct inspirations for writing this was a short story that crossed my desk that was a thinly disguised version of one of the classics of the field. When I told the author about the trouble he could get into if any editor failed to recognize it and published it, he wrote back that he suspected that, but wasn't familiar enough with copyright law to be sure; so he sent it to me not because he expected to sell it, but to get my reaction. He wrote it because his daughter had read the original and complained that it was "old" and "out of date." So he went through it, changing names and making tweaks to "update" it, replacing things like slang and technological background details that the original author had imagined in the 1940s with ones that he might have used in 2000. The updater's daughter liked the new version much better, and wanted to pass it on to her friends. At that point the author became concerned about the legal and moral acceptability of doing that, so he showed it to me.

The incident points up a real problem, long familiar to literature teachers: how do you make people see that even "old" and "out of date" art can still be enjoyable and worth reading? The father's effort to make an older story appealing to a new group of readers who would otherwise dismiss it as "irrelevant" is commendable. But it's disturbing, on at least two levels, that the effort should be necessary. Why must so many readers have things expressed in terms of the very narrow slice of experience they live in before they consider it worth their attention? And when you tinker with a story in ways like this, do you call the result a new and (arguably) improved version of the original, even though it is clearly not the original and might not be approved by the original author? Or do you call it something completely new, even though it isn't?

It depends at least partly on how radical the changes are. If the reviser tries to stay as close as possible to the look and feel of his prototype, as I think he did in this case, the result may be commendable in the sense of being very faithful to the spirit of the original while getting it

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before a new audience—but if he publishes it, any court will treat it as plagiarism. At the other extreme, a writer may take a bare-bones idea from an old story and use it to generate an entirely new one worth attention in its own right. The inspirational debt Leonard Bernstein and Stephen Sondheim's *West Side Story* owes to William Shakespeare's *Romeo and Juliet*, or Richard Adler and Jerry Ross's *Damn Yankees* to Johann Wolfgang von Goethe's *Faust,* is obvious. But what makes the newer works worthwhile is not any "relevance" that they add to the earlier stories, but the new and original things their authors did. If you've seen and enjoyed *West Side Story* or *Damn Yankees*, fine—but that does not mean there's no point in your also seeing or reading *Romeo and Juliet* or *Faust*. (Besides, Shakespeare and Goethe borrowed from earlier sources, too!)

Between those extremes, we often see things that excite certain critics, but seem to many of us . . . well, silly. I refer to such things as directors who feel some weird compulsion to stage Shakespeare plays or Verdi operas in modern dress, retaining the original dialogue (sometimes with topical interpolations) but setting them in, say, the South Side of Chicago in 1940. People from different periods and cultures do have similarities—some of my English teachers seemed positively obsessed with identifying things that were "universal" and "timeless"—but they also have differences. Some stories can only be understood in terms of the particular cultural context in which they're set. If we are ever to achieve *understanding* across such divides, we must learn to look at other people's situations from *their* point of view. If, to give a hypothetical example, the Blitherians and Blatherians have been locked in conflict for decades, their problems will not be alleviated by either pretending that the other side is "just like us," or by retelling Blatherian stories with Blitherian names. But there may be some relief if Blatherians can make an effort to see how their mutual problems look to Blitherians (who have quite a different view of things)—and vice versa.

Science fiction, of course, has a slightly different version of the problem. Verdi's *La Traviata* would be hard to set in 2001 New York because the plot hinges on a set of social attitudes that once existed and are radically different from those of here and now. We know what they were, and fidelity to the story is a matter of accurately portraying certain aspects of the past. Most science fiction is not set in the past, but in a future as imagined by somebody in a particular time and place. As time passes, the world will inevitably develop in ways that were not foreseen by any particular imaginer, so it may become increasingly clear that the real world of a certain time will not look like the version somebody imagined years earlier. That's what bothered the young reader I mentioned earlier, and what her father tried to fix with his revision. But even his updating, however well-intentioned and skillful, would not really solve the problem. If the story in question was set in 2010, an update done in 2001 will surely show new discrepancies in five years or less. (As it happens, this particular story was set very close to 2000, so the "update" already wasn't—it had to be moved up to a later time to allow for things that haven't happened in the real 2000.)

I've recently had to give considerable thought to this problem and what, if anything, to do about it. Several of my own out-of-print novels were being reissued in various digital formats, and one of the editors offered me the chance to make any changes I wanted in the new versions. I thought about it, and decided to make only a few very small, very obvious tweaks. A serious attempt to *really* update *The Sins of the Fathers* and *Lifeboat Earth,* for instance, would re-

Continued on page 137

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What you think
you see is not necessarily
what you get. . . .

The King Who Wasn't

Lloyd Biggle, Jr.

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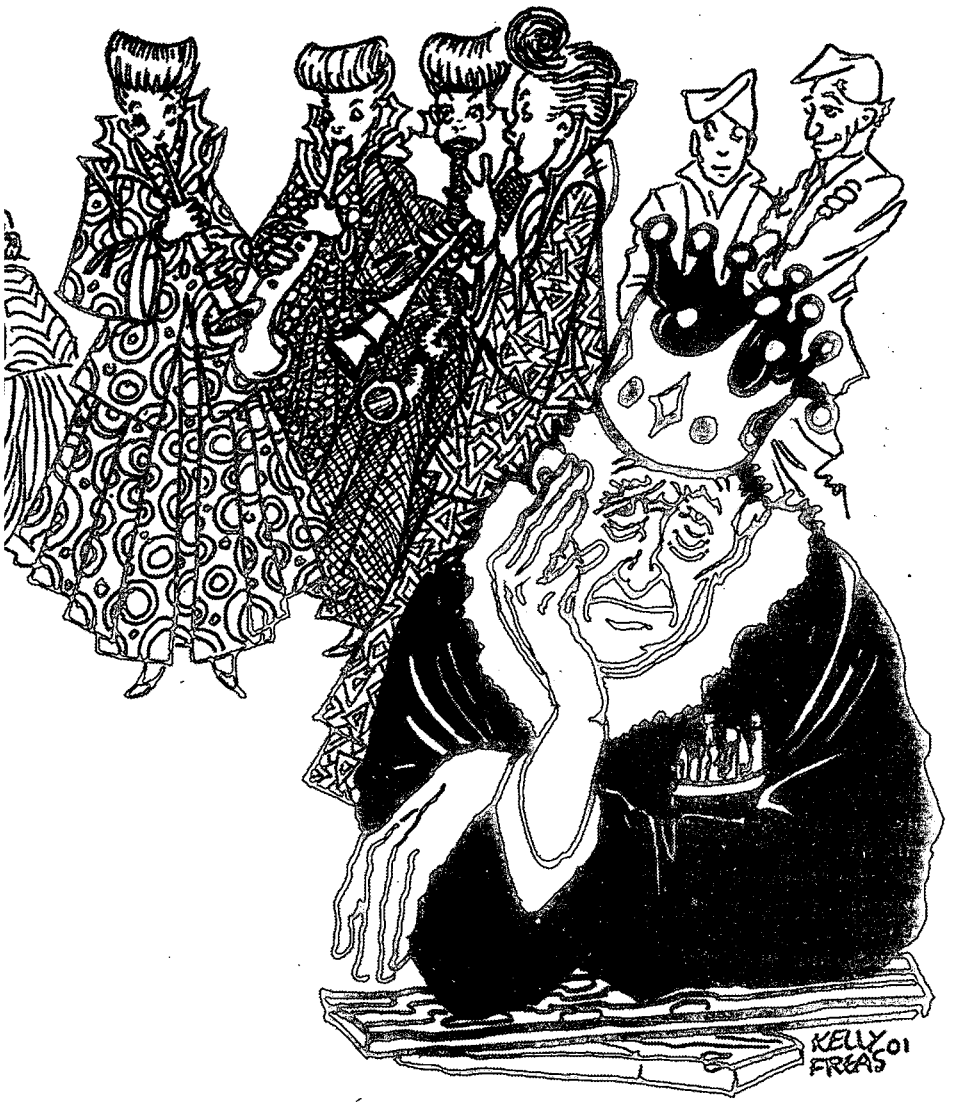
Illustration by Kelly Freas



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When Jedd Lefarn reached the broad avenue that led to the front gate of the Zwaal Market, it was packed with a surging and screaming mass of outraged citizens. The uproar was incessant, and the air near the market was filled with missiles—rocks, paving stones, chunks of firewood, fruit, tubers, anything that could be thrown.

Lefarn's impulse was to leave, but he was an Interplanetary Relations Bureau Agent, and he had a job to do. The citizens of this world of Nylyant had the reputation of being the most orderly and law-abiding in the sector. Their governments were model democracies, their political leaders were chosen at regular intervals by orderly elections in which all citizens who had reached adulthood freely participated, and these leaders followed the will of the people in all of their actions. If they didn't, the citizens had the power to throw them out at the next election, and usually they did. As a result, nothing ever happened on Nylyant.

Suddenly something *was* happening, something so violently out-of-character that it made all of the IPR Bureau's accumulated wisdom about the world look silly. Lefarn's first duty was to record as much of it as possible. Inside his ragged shirt, a tiny teloid camera was affixed to his chest. Teloid cubes taken by the camera would project three-dimensional temporal images of the uprising—with full color and sound—for the edification of IPR personnel at the CB, the world's Command Base—but only if Lefarn had the good fortune to survive the riot and get them safely back there.

Before he could begin, he had a problem to solve. In this churning crowd, he would be recording nothing but the backs of the people in front of him. Looking about, he noticed a close neighbor on his right who was waving two flags—multicolored rags, really—fastened to meter-long sticks. Shouting to make himself heard above the din, Lefarn offered to buy one of the flags. The neighbor, a blacksmith according to his leather apron and gauntlets, grinned, shrugged, and ceremoniously made him a present of it. Lefarn deftly effected a sleight-of-hand transfer to place the tiny camera at the end of the stick. Held high above his head, the teloids it took would give the CB staff a better view of the riot than Lefarn had.

He slowly edged his way through the crowd, turning this way and that and trying to make certain that the camera recorded the scene as fully as possible. It took him half an hour to get close enough to the market gate to see what the target was for that strange assortment of missiles. When he finally succeeded, the sudden revelation sickened him.

The city's six highest elected officials, the Ronzwaal or state council, were tied to upright posts erected on a wagon bed. Men, women, even children, their faces contorted with rage, were throwing anything that came to hand. For the most part their aim was poor, but in such a sustained barrage an occasional missile was bound to do damage. By the time Lefarn caught a glimpse of them, the officials were battered and bruised and spattered with ripe fruit from head to foot. Their faces were swollen and bleeding, and one of them seemed to have a broken arm.

Lefarn knew little about them except that they were astonishingly unpopular for politicians who had been freely elected by their constituents. They were the butt of an incessant litany of complaints about high taxes, and each night the city's taverns rocked with the raucous insults the citizens directed at them. Lefarn, a lowly gwarnt or peddler, had no contacts of any kind with members of the city's Ronzwaal and rarely caught a glimpse of them, but from the little he saw and heard, they impressed him as a prize collection of nitwits—he had wondered, in fact, how such ignoramuses could have got themselves elect-

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ed, but he certainly would not have anticipated this fate for them.

As Lefarn maneuvered to give his camera a better shot of the scene, he saw for the first time that the crowd was—at a safe distance—carefully overseen by police officials. It was unclear whether their function was to keep the crowd from going too far or to prevent the Ronzwaal's escape. Nothing was being done to shield it from the missiles still filling the air.

At that moment a good-sized rock struck the Zwaalant, the government's highest official, squarely in the face with a spattering thud. Bones were crushed, teeth flew, blood spurted. The crowd sent up a cry of triumph and began throwing things with renewed vigor.

Lefarn turned away, appalled. His camera had caught enough, and he had no desire to stand there and watch six living persons stoned to death. He transferred the teloid camera to a safe pocket, abandoned the flag staff, and began to edge back through the crowd. Just as he thought he was making good his escape, he found a wagon blocking his way. A single burly individual, clad in the black cloak the city's bureaucrats affected, was in the act of climbing onto it. He quickly assumed the role of the riot's master of ceremonies, and his bellowing voice silenced the crowd.

"If you don't want these scoundrels to be your Ronzwaal, what do you want? Another Ronzwaal to take their place?"

"No!" a thousand voices chorused.

"What do you want, then? A Yaro?"

Lefarn couldn't remember ever having heard the word.

The voices chorused, "Yes! A Yaro!"

"Who do you want for Yaro? You have the right to choose freely." He paused. Lefarn, looking up curiously, found himself the object of serious scrutiny. A nod, and hands seized Lefarn. Before he could protest, he was hoisted onto the wagon.

"Do you want him for your Yaro?" the voice demanded.

The crowd chorused, "No!"

If any of them knew Lefarn at all, it was as a humble gwarnt, a street peddler who made regular appearances in the Zwaal market. In this society, peddlers were held beneath contempt.

Lefarn was summarily tossed off the wagon. He landed on his feet, stumbled, fell. He scrambled up and began to edge away. Public scrutiny was one thing any IPR agent strove to avoid, and his instinct told him to put as much distance as possible between himself and the market and keep under cover until the crowd had forgotten him. Determinedly squeezing his way between people, he had managed to progress a few meters—with two stops to watch other candidates for Yaro rejected and booted off the wagon—when a loud cheer halted him again. He looked back and saw a fat, blubbering old idler hoisted into view. This was Hoxton, whom Lefarn had known from his first days in Zwaal. Hoxton was a popular local character and, as market clown, a great favorite with both children and adults. He also was the only close friend Lefarn had. When Lefarn first arrived in Zwaal, unfamiliar with local customs and speaking the language imperfectly, it had been Hoxton who sheltered and protected him, taught him what he needed to know, and found work for him. At the moment there was nothing Lefarn could do for him but watch to see what would happen.

"Do you want him for your Yaro?" the voice demanded.

"Yes!" the crowd shouted.

"You have a Yaro!" the voice bellowed triumphantly. "Now—the Yaro must choose his Illyar. What is Your Eminence's choice?"

Hoxton turned on the master of ceremonies "What's a Illyar?"

"Minister," the master of ceremonies said. "Assistant. First servant."

Hoxton scrutinized the crowd. His gaze came to rest on the only friend in sight, Lefarn. He pointed. "Him," he

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said. Before Lefarn could resume his retreat, police officers quickly forced their way through the crowd and identified the object of Hoxton's unsteadily pointing finger. Lefarn was seized again, marched back to the wagon, and hoisted onto it.

"Is this Your Eminence's choice?" the master of ceremonies demanded.

"Sure is," Hoxton said. He laughed uproariously.

"So be it." The burly individual turned to the crowd again. "You have a Yaro and an Illyar, and they will soon form a new government and do something about those taxes."

A wild cheer went up. The wagon, pulled by two lumbering gossels, followed a company of police who cleared the way for it. Lefarn looked back. The crowd had resumed its bombardment of the unfortunate Ronzwaal.

Hoxton was still laughing. "Leffi, my lad, we should have some fun with this. Why so glum?"

"Tell me," Lefarn said. "Has the city of Zwaal ever had a Yaro before?"

"I dimly recall something like that from my childhood. It certainly hasn't had one in the last fifty years."

"And what does a Yaro do?"

Hoxton nodded at the master of ceremonies, who was in the act of climbing off the slow-moving wagon to mount a waiting darif, a horselike animal that a police officer was holding for him. "I asked him that while they were helping you onto the wagon. He said a Yaro does whatever he wants to do."

"How many other cities have Yaros?"

"None that I know of."

Lefarn nodded grimly. He already had deduced that the Yaro was a kind of king. Having chosen a leader with unlimited power, the people were certain to expect prompt and substantial improvements in all of the things that irritated them.

"We're in trouble," he said. "You saw how the people got rid of the Ronzwaal when they finally had enough of it. They'll get rid of their Yaro, and his Illyar, and the rest of his court the same way. They are fed up with taxes, and they'll expect the Yaro to do away with them, but governments have to have taxes. They'll want sewage and water improvements, and better streets, and something done about the housing shortage, and those things take time and money. The only way to get the money will be through more taxes. Your Eminence's reign is certain to be a short one. From the mood the people just demonstrated, I'd give us about fifteen days. Twenty at the most. Then we'll be tied to the posts. After all the practice your subjects are having today, they are certain to be more accurate next time. Zwaal impresses me as an excellent city not to become a public official in."

Jedd Lefarn had joined the Interplanetary Relations Bureau in order to see the galaxy. Instead, he found himself as tediously mired on a single world as if he had stayed home. IPR personnel who had high linguistic indexes masqueraded as natives. They put down roots on strange worlds, made careers for themselves—sometimes several careers—and worked hard to master every small detail they were required to know in order to render a flawless impersonation of a native. The Bureau's mission and their lives depended on it.

Unfortunately, it was brutally hard work. Exacting work. Dangerous work. Tightroping across volcanoes would have been simple by comparison.

The problem on the world of Nylyant was one of the most unusual the IPR Bureau had even encountered. The system of government was, as far as anyone knew, unique in the Universe. The IPR Bureau's mission—on every world outside the Galactic Federation—was to guide the natives toward a minimal level ten democracy, thus making the world eligible for membership in the Federation. This had to be done in accordance with a stringent code of rules and with-

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out the natives knowing there were aliens among them.

When the IPR Bureau arrived on Nylyant, it discovered that the world's native population, stumbling along with no outside assistance, had already achieved working democracies. They were not worldwide or even continent-wide, however. The political units were what had once been called, in an early stage of history, city-states, but they were city-states such as no historian would have been willing to believe.

They were walled cities, the walls dating from a remote time when violent confrontations between cities were common. The present city-states had no armies, nor was there a need for any. Wars belonged to the planet's all-but-forgotten history. Each city-state possessed an enormous police force, however, that apparently functioned solely to control the city's own citizens—who didn't need it. Nowhere else in the galaxy were citizens so admirably disciplined.

Each city-state controlled a chunk of the surrounding countryside, and along the perimeters, the rural inhabitants seemed to decide for themselves which city they chose to belong to. Prices they received for meat and produce, and prices city merchants charged for the supplies they had to buy, may have influenced their decision.

The governments were true democracies, however. In every election the IPR Bureau had been able to observe, the citizens "threw the rascals out" and elected an entirely new slate of officials. Having achieved what should have been an ideal system of government, they lived in a state of perpetual dissatisfaction with it. They complained incessantly, and their seething anger was certain to erupt on the next election day and bring in another new slate of officials. Invariably those new officials would raise taxes a bit further, and neglect their duties a bit more drastically, than the previous administration had, with the result that they, too, would be tossed out the first time the electorate had an opportunity.

The IPR Bureau did not know what to make of such badly-run governments. It classified the world O/O, meaning Study and Observation Only, placed a few agents in widely-scattered cities, established a CB, a secret Command Base, in an inaccessible mountain range, and gave it a skeleton staff that had little to do except pass along to Sector Headquarters summaries of the reports its agents sent in whenever they had anything to report, which was seldom.

Jedd Lefarn was one of those widely-scattered agents. Every morning he arose before dawn, walked with his creaking four-wheeled cart—which was pulled by a twal, a goatlike animal and a great pet—all the way across Zwaal to a larcenous wholesaler of fruits and vegetables, selected his merchandise for the day, had the full price—plus a ruinous amount for taxes—extracted from him in coins of the realm before the wholesaler's slatie, or lad of all work, would place a single tuber or fruit in his cart, and then wearily made his way back across the city to the market where he spent hours trying to dispose of his stock. His evenings were devoted to pursuits designed to better the IPR Bureau's understanding of Nylyant.

He had long since abandoned his idea of seeing the galaxy. The enigma of the world of Nylyant had possessed him. He already knew that IPR Bureau agents worked far harder than anyone else, anywhere. Now he knew why. It was the price of knowing a world well, and it was worth it.

He was cultivating a reputation for himself as an ambitious, industrious young gwarnt who was destined to get ahead. He personally had grave doubts that those sterling qualities would carry a humble gwarnt very many steps up the ladder of Nylyantian social and economic success, but that was none of his concern. Further, the strange hereditary traditions and rigid guild structures that

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had the force of incontestable law in the city made it certain that neither a gwarnt nor anyone else could ever change occupations. Once a gwarnt, always a gwarnt—but that was none of his concern, either.

At the moment, his problems were not with the world of Nylyant, but with his commanding officer. The IPR Bureau coordinator of a world classified O/O held what many considered the Bureau's most choice assignment. He had little to do, and the Nylyantian coordinator, Elwin Stantlor, managed to make a mess of that little. He seldom emerged from his headquarters aerie except when he was vacationing at the uninhabited island paradise that headquarters personnel used for rest and recreation. He knew nothing about Nylyant except what his agents told him. He rarely issued an order, and when he did it was through his niece, Raisa, who acted as his assistant coordinator and who knew even less about Nylyant than her uncle did.

The niece was a bitch of the first order, most ignorant of what she was most assured, as some poet had aptly put it, and she flaunted her ignorance. Lefarn had collided with her by way of his communicator the previous evening, and he was still seething. Two days before, she had ordered him to obtain the floor plans of several buildings in the Zwaal Faqzwaal, the walled inner city where the elite lived, and she was needling him because he hadn't carried out the order. Lefarn had no idea how to get into the Faqzwaal, let alone the buildings, and no native he knew had ever seen the place except from the other side of its high wall. Lefarn was treating this order as he treated all of his orders. He carried them out when he could to the extent that he thought he had to.

As for Raisa Stantlor, she was homely, she dressed with deplorable taste on any occasion when she couldn't wear her uniform, and she always wore, in uniform or out—contrary to regulations when in—the most hideous necklace Lefarn had ever seen. It was a clutter of black plastic odds and ends, and the notion of any creature adorning itself with such unattractive trash inspired nightmares. Lefarn had great difficulty thinking of Raisa Stantlor as female.

The problem of the Stantlors, uncle and niece, was one that time would resolve. Eventually there would be an unannounced inspection of the CB and the planet, and both Stantlors would be disposed of, leaving Lefarn with one less problem to confront. The world of Nylyant was already providing more problems than he could handle.

After almost a year of residence in the city of Zwaal, what he had observed of the city's governmental, economic, and social systems made no more sense to him than it had when he arrived. The longer he contemplated them, the more he was convinced that there was something radically wrong. He refused to believe that they worked.

Despite this unresolved enigma, which preyed on his mind constantly, he managed to enjoy himself much of the time. The market people were the pariahs of Zwaal, and he liked them. He delighted in their antics and zany conversation. He helped them whenever he could. One advantage the IPR agent had was financial. Coins counterfeited at the IPR Base were identical to those produced by the official Nylyantian mints. As long as Lefarn was able to convince people that the money he disbursed had been acquired through his own hard work, he could spend as much as he liked. He used the money to help the unfortunate and to buy treats for their children. Among market people, he was easily the most popular gwarnt in Zwaal.

He had been plodding wearily through the dilapidated streets day after day, going through the motions of earning a living, without a glimmer of a suspicion that the city was about to explode, but it had done so, and done it on a market day that began like any other. Lefarn, his wagon loaded with fruit, had

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been one of the first vendors to arrive. A scattering of early customers drifted through the market—housewives in colorful drapery, drably-dressed males uncertainly performing errands for their wives, all hoping to find the most choice produce before the late-morning crowds had a chance to pick it over.

Old Marfley, the market's official sand sculptor, had made his usual, swaggering entry, pushing a cart laden with a vast clutter of tools and also a crock of water. His assortment of knives, shovels, spatulas, picks, molds, and templates, along with the strange coverall he wore, made him look equipped for tasks of a highly technological nature such as the overhaul of an atomic engine. He went directly to his sand box, and during the course of the morning he would create a landscape, or a section of the city, or something entirely fanciful, all in sand.

The Bylyf brothers, gymnasts and wrestlers, took over their ring and began a series of demonstrations. As a new arrival, Lefarn had been enticed into a match with the smallest of the five brothers. All of the marketers gathered around to enjoy the joke—but Lefarn's IPR Bureau training had included unexpected odds and ends, sports among them. With a skill completely unknown on Nylyant, he had easily thrown the muscle-bound Bylyf brother, who relied on strength only. The brothers were more awed than resentful, and thereafter they considered Lefarn one of them.

The market orchestra arrived in a colorful flutter. "Musician" was exclusively a female occupation on Nylyant, and the orchestra's robes were even more spectacularly patterned than those of the housewives. Its members twanged on massive, long-necked chordophones or honked on diminutive, lip-vibrated aerophones, and the conflicting result sounded, to Lefarn, like two ungainly animals battling to the death. But occasionally he joined them and managed to coax from an awkward chordophone sounds that the musicians had not even imagined. To the members of the orchestra, also, Lefarn was easily the market's most popular gwarnt.

A straggling group of police officers followed, their yellow-brown uniforms pressed into stylish creases, their brass buttons and buckles polished to a sheen that would not last through the morning. The officers settled into a small stone structure at the center of the market. They were there to maintain order, but Lefarn had never seen any disorder in the Zwaal market. Since the police had nothing to do all day, they occupied themselves with getting drunk, a task which they performed with enthusiasm.

Finally, when the full rush of customers was about to descend on the market, the massively fat Hoxton arrived. During Lefarn's first bewildered days in Zwaal, Hoxton had mistaken him for a naive farm boy who had fled some trifling scandal in a nearby city. By protecting him and getting him established as a gwarnt—the only occupation open to him—he almost certainly had saved Lefarn's life. The mortality rate among agents on a new world was shockingly high until a few agents developed survival skills and could train others.

Lefarn had more than returned the favor. When Hoxton was ill—or sleeping off a massive drunk, which amounted to the same thing—Lefarn cared for him, nursed him, fed him, and kept him in funds until he was able to return to work.

On this day, the demand for fruit had been greater than usual, and Lefarn hoped to sell out early and escape from the sweltering market. Then an astonishing thing happened. A citizen he knew well, an elderly merchant who always wore a yellow sash and scarf, stooped, pried loose one of the cobblestones that paved the market, and threw it in the direction of the police pavilion. Since the pavilion was not a small target, he should have hit it easily, but the stone

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was too heavy for his advanced years. It landed a full meter short of the pavilion and rolled against its door with a thud.

An officer looked out with drunken curiosity. The incident was beyond his comprehension, so he turned away—and thus failed to see two better-aimed cobblestones, one of which crashed against the door and the other of which found its way through an open window and hit an officer squarely in the back.

Before the police could untangle cause and effect from the churning market activity that surrounded them, a barrage of cobblestones was thudding against the building. The officers took refuge behind chairs, behind tables, behind anything that could serve as a shield while their captain tried to figure out what was happening.

The barrage soon began to slacken, but that was only because the market customers quickly exhausted those cobblestones that were easily pried from the ground.

At that moment Lefarn himself inadvertently played a minor role in this most unlikely of revolts. A market customer came up for air after struggling vainly to extract another cobblestone, and his eyes chanced to fall on Lefarn's remaining stock of fruit. He thrust a handful of coins at Lefarn. "I'll take it all," he said.

Lefarn wisely decided not to worry about the amount until he had put a safe distance between himself and the turmoil. When, long afterward, he finally thought to count the money, he discovered that his accidental participation in a revolution had netted him a handsome profit.

The purchaser divided Lefarn's fruit with bystanders who wanted it, and Lefarn immediately set his twal in motion and began to edge his cart through the crowd toward the market's rear exit. Once he reached it, he hesitated.

Behind him, the din of the uprising was crescendoing. Any gwarnt with a rudimentary survival sense would have salvaged what he could and taken to his heels. Lefarn had been about to do so, but at that point his IPR training intervened. Something inexplicable had occurred, something that might have a dramatic impact on the IPR mission on Nylyant. As far as he knew, he was the only IPR agent in that quarter of the continent. The opportunity might not occur again for a decade or a century. His responsibility was not to act for his own safety but to record the uprising in as great a detail as possible.

A fellow gwarnt pushed past him in a panicky attempt to reach the gate ahead of Lefarn. Lefarn called to him, "Ha, Loare! I can't leave yet. Take my wagon and twal home for me, will you?"

"Sure thing," Loare said. He owed Lefarn more than a few favors and expected to owe him more. He placed his handcart on Lefarn's wagon, set the twal in motion, and vanished through the exit.

Lefarn turned back toward the riot with no expectation of colliding with destiny. He was only collecting information for the report he would be expected to write. Because he could see nothing at all of what was happening on the other side of the market, and since forcing his way through the packed crowd looked impossible, he ducked out of the rear entrance and by a circuitous route through narrow streets of weathered, rickety wood dwellings and shabby shops, reached the broad avenue that led to the market's main gate.

The crowd was greater there and the turmoil more violent. Again Lefarn shrugged off an impulse to leave. He acquired the flag, attached his camera to the staff, and began taking teloids of the riot, forcing his way through the crowd all the way to the market gate and the wagon where the city's officials were being stoned to death. Then came the astonishing turn of events that made him one of the rulers of Zwaal.

Although Lefarn had lived in the city

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of Zwaal for almost a year, he knew little more about its geography than the average gwarnt. The early years of an IPR agent's assignment were devoted to staying in character and trying to stay alive. Lefarn knew the poorer parts of the city thoroughly. He knew the routes to his wholesaler's and to the market. He knew all of the taverns patronized by his social class and the merchants who would condescend to sell to him—at inflated prices—the essentials he had to have, including coal for cooking his food and the rags he wore. He also knew every potential hiding place in the parts of the city he frequented, which were the lower parts. That knowledge was essential to his survival.

The upper parts of the city he knew only from IPR Bureau aerial photos and from reports and rumors that surrounded his own wormlike existence. The city was spread over a vast hill, and the higher one went, the less smog there was from the sulfurous coal the Zwaalers burnt the year round for both heating and cooking, and the more desirable the neighborhood. If Lefarn had ventured into those upper regions, police would have quickly noted his presence and evicted him. The shack where he lived and stabled his twal was very near the bottom where the poorer quarters merged with outright slums, and he often had difficulty breathing or even seeing across the street.

At the top of the hill, fully a third of the city was encircled by a tall stone wall. This city within a city was the Faqzwaal, the forbidden sector, where the rich, or the gentry, or the peeragers, or the Faqzers, or whatever they chose to call themselves, lived. Commoners knew almost nothing about them, for there was virtually no contact between the two classes. The Faqzers rarely visited the city proper. Their homes, except for roofs, were invisible beyond the tall wall. A narrow stretch of park land, also enclosed by a wall, with a broad avenue at its center, led down the hill from that walled section to the Faqzers' private city gate and, beyond it, to open country. This enabled the Faqzers to frolic at their communal retreat on a nearby lake, or to visit other cities, without exposing themselves to the bottom-of-the-hill squalor of the area where Lefarn lived.

As for what sort of people the Faqzers were, and how they had acquired their wealth, and what kind of lives they led behind their tall wall, these answers were part of the Nylyantian enigma. Lefarn knew nothing at all about the Faqzers. He had once caught a glimpse of two of the men, stylishly clothed and casually affecting an air of being lord of all they surveyed, when they called on a goldsmith whose wife sometimes bought from Lefarn in the market and asked him to deliver her purchases.

Precisely what role the Faqzers played in the Nylyantian democratic system was a critical question and the most important of the Nylyantian mysteries. It was especially a mystery to lowly IPR Agent Lefarn, who—according to the snotty Assistant-Coordinator Raisa Stantlor—should have been able to explain such things. Now he was Illyar of the city, being carried toward his destiny by a lumbering wagon, but he had no sense of being any closer to the mystery's solution.

After a short ride surrounded by their cheering subjects, the new Yaro and his Illyar were transferred to an elaborate carriage, something rarely seen in the city, and whisked away by a team of sprightly darifs to the new Yaro's residence. As they climbed the steep streets, both Lefarn and Hoxton moved into lofty regions the police would have forcibly expelled them from the day before.

High up on the hill, built against the Faqzwaal wall, were the municipal buildings. They stood like stair steps: The one-story building was police headquarters; the two-story building housed the municipal offices; the three-story building was derisively known as the

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palace. It was a shabby stone structure where the Ronzwaal and their families had lived. These had already been evicted; along the way, the Yaro's carriage met wagons loaded with weeping wives, children, and heaps of personal possessions. The palace was now the Yaro's residence. Waiting for them inside, resplendent in a blue and gold uniform, was the burly individual who had played master of ceremonies at the revolution. He met them with a sweeping bow.

"What orders does Your Eminence have?"

Hoxton regarded him suspiciously. "Orders? You said the Yaro could do anything he liked. How does it happen that I have to give orders?"

"You don't 'have to.' If you want to, then my duty is to carry them out."

"Excuse my ignorance and curiosity," Lefarn murmured. He paused for a deep breath. He was having difficulty comprehending the dazzling leap from gwarnt to Illyar. He still felt like a humble peddler. "Who are you?" he asked.

"I am Dagget, His Eminence's Administrator."

"I see. And did the Zwaalant who just met such an unkind fate at the market have an Administrator?"

"He did."

"Who was that Administrator?"

"I was," Dagget said blandly. "Administrators serve for life whatever government is in power."

"And what sort of orders would a Yaro be expected to give at this time if decided to give any?"

Dagget shrugged and said lightly, "He might order free beer served in the city's squares for ten days in celebration of his elevation. The people are certain to expect festivities."

"Now that is something like!" Hoxton guffawed. Then he had a sobering thought. "Who will pay for this beer?"

"Your Eminence will. Meaning that the government will."

"And does the government have money for ten days of beer for the whole city?" Lefarn demanded.

"If His Eminence commands it, the money will be found."

Lefarn felt himself confronted by a host of uncertainties. The one thing he knew for certain was that he needed time to think. "Before delivering any such momentous orders, His Eminence would like to eat," he said. "So would I. How do we go about getting food?"

"You have only to ask," Dagget said. "Your midday meal will be served in your dining salon at once if you command it."

"We are not accustomed to commanding things," Lefarn said, "but we do earnestly request it."

The food was the best Lefarn had eaten on this world of Nylyant, and that included the rations served at the IPR CB, which were spartan. The choice cuts of several kinds of meat were expertly cooked and sliced, the baked vegetables had been whipped into a frothy delicacy, there were pitchers of wines and beers, and a side table was laden with tempting fruits, cakes and pies. The food was served by five elderly servants, three men and two women. Once it had been placed on the table, Lefarn shooed the protesting servants out.

"We are not accustomed to being watched while we eat," he explained.

As soon as they were alone, Lefarn spoke to Hoxton in hushed tones. "Keep your voice down. They—or someone—may be hiding nearby. We're in serious trouble, and we should talk about it."

"Why do you say that? The Administrator and all the servants will do anything we ask them to."

"When we give them an order, we will have no way of knowing whether they actually carry it out. That's one problem. Another is that they may subtly suggest things that will arouse the people against us. The beer, for example."

"How will that arouse the people? It

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ought to make me popular."

"How popular will you be with the tavern owners if no one in the entire city buys beer for ten days?" Lefarn demanded. "How popular will you be with the wives of the city if you keep their husbands constantly drunk for ten days? Tavern owners are the most influential class of people on Nylyant. As for the wives—did you notice how many women were throwing stones at the Ronzwaal?"

"You mean—I can't do anything?"

"Before you do anything at all, you should weigh the consequences carefully. Everything that oily character Dagget suggests should be viewed with deep suspicion. One reason we're in trouble is because this palace is filled with his people, and we don't know who he is working for. We desperately need some of our own people around us, someone who will be working for us, but I haven't been able to think of a way to manage that. Without our own people, we're completely cut off from the outside. We'll have no notion of what is happening and what the people are thinking."

Hoxton was staring at him. "Cut off? Do you mean we're prisoners?"

"We don't know what would happen if we tried to leave. We can easily find out by making the attempt, but we don't dare let Dagget know we're even thinking of such a thing."

"What are we to do?"

"Finish your food. Enjoy it. We don't know how many more meals like this we'll survive to eat."

They ate; they called the servants back to clear away the remnants of their meal, and then the two of them, after changing into the plushy black clothing with gold cloaks that had been provided for them, went to a window at one end of the Yaro's study and looked out. There was a balcony, and after a moment's consideration they went onto it and contemplated the new Yaro's realm—dimly, through the thick smog that hung over the dirty, crowded city below them. Beyond the massive stone city wall was a lovely sweep of countryside; looming in the distance was a low mountain range. Zwaal was surrounded by mountains.

The world of Nylyant was famous for its sunrises and sunsets. Within the city, these had to be perceived through a haze of stinking, sulfurous coal smoke. Respiratory ailments were epidemic among natives as well as IPR Agents.

If they turned to their right, they could look over the tall wall that surrounded the Faqzwaal and contemplate some of the large homes of the wealthy, each set in its own tidy garden and resplendent in the clearer air of the hilltop. The Faqzwaal provided a stark contrast with the remainder of the city. Nothing about it was crowded. Everything looked clean.

Lefarn stared at it in deep puzzlement, attempting to reconcile it with the knowledge of Zwaal he already had acquired. Try as he would, he couldn't make the city work—couldn't connect the filthy expanse below him, strangled with taxes and populated with small groups of craftsmen and entrepreneurs and large groups of laborers, with the view he had of the Faqzwaal. The contradiction made no sense either socially or economically.

The government itself and its three buildings that were heaped against the Faqzwaal wall seemed to be the only link between those two worlds. The buildings may have been connected to that high sanctuary through doors in the wall. Perhaps Dagget and his fellow administrators lived in the Faqzwaal and worked in the administration building, looking after the various departments of the city's government.

Was the Faqzwaal a complete city unto itself, with shops and tradesmen to service its population and a market square patronized, not by housewives, but by their maids, who shopped each morning for the family's provisions? If

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so, these were invisible to him. He could see only a third or less of the Faqzwaal's area.

Perhaps it held the clue that would eventually unravel the enigma of Nylyant, but the mystery of how he and Hoxton were to get out of the predicament they were in confronted them much more urgently.

Dagget returned to ask again whether they had any orders for him. Lefarn invited him to join them, and they took chairs at a small conference table.

"First," Lefarn said, "we would like to replace the character who drove the Yaro's carriage. He nearly ran down a child on the way here, and the Yaro cannot risk accidents of that kind. They would make him extremely unpopular."

"I agree," Dagget said smoothly. "I'll have another assigned to you."

"After that experience, the Yaro would prefer to choose his own. He has a friend who is an expert driver. I will call on him this evening and see if I can persuade him to become the Yaro's driver."

Dagget's smooth visage wrinkled into a frown. "I'm afraid that wouldn't be—"

"Surely the Yaro's authority extends to selecting his own servants," Lefarn said.

"Of course it does."

"Further, it is critically important that I make some arrangements with regard to my own affairs. I was only a humble gwarnt, but I owned my own twal, and I must see that he is properly looked after during my absence."

Dagget looked at him with astonishment. Then he laughed. "You, the Illyar, are worried about your twal? Have you any idea what the Illyar's salary is?"

"No," Lefarn said, "but I doubt that it matters much because I don't expect to be Illyar very long. I'll need the twal urgently when I become a gwarnt again."

Dagget thought that hilarious, but now he was regarding Lefarn with something like respect. "Very well. You may go this evening and find a new driver for the Yaro and make arrangements for your twal. Anything else?"

"Yes. With regard to your suggestion that the city be given free beer for ten days—"

"Of course. Shall I make the arrangements?"

"No. In the morning we would like to confer with the city's brewers to determine the most economical way to arrange some kind of celebration to honor the new Yaro. Also, after we have seen the brewers, we would like to confer with the person who looks after the city's finances and maintains the records. Ask him, please, to bring the latest financial statements with him."

Dagget's look changed to one of profound suspicion. "The Yaro need not concern himself with matters like that."

"The problem," Lefarn said, "is taxes. The people are overtaxed. They are on the point of revolt. Yesterday they did revolt, which is why they now have a Yaro. If their discontent continues to grow, even the city's administrators may find themselves tied to posts in the market."

Dagget winced.

"Unfortunately," Lefarn went on, "taxes are necessary. The problem is to maintain the taxes the government needs while giving the people the impression that taxes have been substantially reduced."

This was totally unexpected to Dagget. He murmured, ". . . while giving the people the impression . . ." He paused; he found the concept difficult to grasp. ". . . giving the people the impression . . . That is indeed the problem. How do you propose to do it?"

"We would like to reduce or eliminate some highly conspicuous taxes—those on food and lodging, for example, which affect every citizen in the city directly and repeatedly every day of their lives—and replace them with taxes that would be less conspicuous and less irksome. We need to talk with someone who knows how much the various taxes bring in so we can better consider the

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problem of replacing some taxes and increasing others."

Dagget nodded thoughtfully. He turned his gaze to Hoxton, turned it back to Lefarn. He spoke with grudging respect. "There certainly would be no harm in discussing that. I doubt that anything positive will result. Unfortunately, food and lodging taxes are our chief income-producing taxes. They bring in very large amounts of money, more than all the other taxes together. But there can be no harm in considering it. We'll discuss it tomorrow with the city's comptroller."

After dark that night, Lefarn changed to his own ragged clothing and made his way back down the hill, taking infrequently used streets and avoiding contact as much as possible. Fortunately he met no one he knew. Loare, his fellow gwarnt, had stabled his twal and put his wagon in its proper place, but he had neglected to provide enough food and water for the animal. The poor creature bleated pathetically when it saw Lefarn. Lefarn fed and watered it and then made arrangements with a neighbor who would see that it was properly cared for.

That taken care of, Lefarn called the CB, the Command Base, on his communicator. No one answered. Frequently no one answered. The Nylyantian CB was unaccustomed to emergencies, and it closed down when it felt like it. Lefarn recorded a description of the day's events, excitedly describing the opportunity that chance had given him to find clues to the mystery of Nylyant. He asked that a pickup be made of his teloid cubes and requested immediate research into the history of Yaros and their Illyars on Nylyant. He left the teloid cubes in his mail station, which was a niche at one end of his shack's roof.

Next he went looking for the Bylyf brothers. He located the muscular acrobats in their favorite tavern, and they—and all the patrons—welcomed Lefarn with a cheer. Lefarn promised them a better government, reminded everyone that changes unfortunately took time, and drew the Bylyfs aside for a conference.

He sent one of them to find the women of the market orchestra. While they waited, he explained the problem to the others: He and Hoxton were virtually prisoners. What they urgently needed were bodyguards—capable fighters who could protect them from the government bureaucrats who surrounded them. They also needed an expert carriage driver or two, but that was only an excuse to sneak more bodyguards into the palace. Especially they needed pairs of sharp eyes that could observe what was going on and report it.

The Bylyfs required very little convincing. Neither did the members of the orchestra when they arrived. They would take over the maid duties at the palace and provide music when the Yaro entertained.

One of the Bylyfs went to find a driver who met Lefarn's specifications. He brought back two, and Lefarn invited them to join his other recruits. He marched back up the hill with a respectable following—the five Bylyfs, the two drivers, and the six women of the orchestra. At the palace entrance, sentries barred the way and sounded an alarm. The reserve guard came pouring out, and their captain tersely ordered Lefarn and his troops away.

Lefarn stepped forward. "Nonsense," he said. "If you can't recognize your Illyar, there will be a new captain of the guard tomorrow. These are servants I have engaged—the Yaro's two new drivers, the special escort that will accompany him on his public appearances, and the palace orchestra, whose members also will serve as maids."

He got them into the palace, found quarters for them, told the elderly house manager to have appropriate uniforms made, and went looking for Hoxton. He expected to find the former clown drunk and asleep, but Hoxton, over-

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whelmed by the serious view of life that suddenly had been imposed on him, was wide awake and cold sober. He cheered up when Lefarn told him what he had accomplished.

"Things look a little better than they did this morning," Lefarn said. He added an aside to himself as he sought his own bed, "Actually they aren't all that much better."

In the morning, the brewers—four ponderous men who were almost as fat as Hoxton, were waiting on them when they finished breakfast. It had been a jolly breakfast, with Hoxton and Lefarn, the Bylyf brothers and the two drivers waited on by the six musicians. It left Lefarn in the best mood possible for a joust with four fat Zwaal brewers.

Dagget joined them. Hoxton hovered in the background, mystified as to what Lefarn was plotting. Before the discussion could begin, Lefarn had to patiently suffer what he considered an excess of formalities. When finally he was permitted to ask questions, he demanded to know how many taverns were operating in Zwaal.

The brewers discussed the question. Then they argued it. Twenty-six was the number finally agreed upon.

"What about the Faqzwaal," Lefarn asked. "Did you include its taverns?"

That hadn't occurred to them. The Faqzwaal's four taverns increased the number to thirty.

"I wasn't in Zwaal at the time," Lefarn said,"but I have heard it rumored that two years ago, during the Rilque, the Festival of Spring, you—or one of you—produced beer that was faintly pink in color. Can you do that again?"

One of the brewers apologetically explained that the pink beer was tinted with a small infusion of the juice of tilz berries. The berries ripened about that time, and the pink beer had been an experiment. It hadn't sold any better than regular beer, and the berries added slightly to the cost, so the experiment hadn't been repeated.

"I want beer of a distinctive color," Lefarn said. "The color will prevent the tavern owners from selling it as regular beer. It doesn't have to be made with tilz berries, but the color does have to be noticeable, and the beer has to taste good. Can you manage that?"

If purple was acceptable, they thought they could manage it. The fruit of the impfer was now available, and its juice would stain the beer purple. One of the brewers had tried it once as an experiment. It had given the beer a distinctive flavor, and those who drank it thoroughly approved.

"Excellent," Lefarn said. "I would like five kegs of purple beer for each tavern. The beer will be supplied free to the tavern owners, and they will sell it at one-quarter their usual price. I'm going to think up severe penalties for any of them who charge more than the one-quarter price, which I make out to be half a waalder per jabo. What's the matter?"

"It won't work," one of the brewers objected. "Taverns in the Faqzwaal don't charge for beer. Or anything else."

That gave Lefarn pause. He filed the information for future use. "Then we won't include the Faqzwaal. Plan on five kegs of beer each for twenty-six taverns. A hundred and thirty kegs in all. And before you flavor the hundred and thirty kegs, bring a generous sample of the purple beer here for us to approve. We want the purple beer available in all twenty-six taverns tonight. The Yaro will visit all the taverns in the city so the patrons of each one can drink to his elevation with purple beer."

The brewers had no objection, but Dagget was totally mystified. "What does all this accomplish?" he asked.

"The tavern owners will make more than their usual profit from the beer they sell, which will please them," Lefarn told him. "All the men in Zwaal will be pleased because their beer will cost considerably less while the special beer

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lasts. It should please their wives because the husbands will be spending less for beer. Now let's see how many people we can please with lower taxes."

The Comptroller entered, followed by two assistants bearing heavy ledgers. Hoxton continued to hover in the background. He considered finances a distasteful subject. Dagget did the same. He, too, considered finances a distasteful subject.

So did the Comptroller and his assistants, but Lefarn didn't learn that until later. It took him some time to master the bookkeepers' cramped scrawl. Once the odd Zwaalion numbers, which looked like convoluted hieroglyphics, became understandable to him, his mind began to form questions.

"This abbreviation. What does it stand for?"

"The Faqzwaal."

"On this date the government bought five wagonloads of vegetables and fruit for the Faqzwaal?"

"But of course!"

"And here—only two days later—three more wagonloads?"

"But of course!"

"And here—the government is buying two wagonloads of meat for the Faqzwaal?"

The Comptroller nodded.

"And here—only a day later—another wagonload?"

"But of course! The people of the Faqzwaal have to eat!"

"Of course they do," Lefarn said. "It's just that I never thought about what it must cost for an entire community to eat, since I've never had to feed anyone but myself." He turned to Dagget. "Now I better understand why so much tax money is required. However, our object isn't to eliminate taxes, but to see whether we can shift the load around. I notice that there are other sources of income, and some of them bring in considerable amounts of money. What does this figure represent?"

"Rents," the Comptroller said.

That brought Lefarn to a full stop. It had never occurred to him that Zwaal was a super-socialistic state where the government owned everything. There was no other explanation. Directly or indirectly, everyone in Zwaal paid rent to the government—indirectly in cases like Lefarn's, who rented a shack at the rear of his landlord's residence. He paid rent to his landlord; the landlord must be paying rent to the city or to someone else who was.

The city owned itself. It was charging rent on its property and collecting taxes on the rent paid, which was a trick so dazzlingly original that it left Lefarn breathless.

Everyone in Zwaal paid rent to the city, and taxes on that rent, with one possible exception. Lefarn had to ask, though he already knew the answer. "Do the people living in the Faqzwaal pay rent?"

The sheer stupidity of the question aroused the Comptroller's indignation. "Certainly not!"

It gave Lefarn one more mystery to ponder. Perhaps that meant that the Faqzers, not the government, owned everything, but he surmised that it would be untactful to ask too many questions of this nature all at once. The more Lefarn learned about Zwaal, the more convinced he was that the city wouldn't work.

Lefarn pointed to the largest figure on the page. "What does this represent?"

"Income from our coal mines."

"The city of Zwaal is selling coal?"

"Of course! We are one of the leading coal producers in the entire region. We are the sole supplier to more than fifty cities that don't have coal. Our coal is the best available."

Lefarn hated to think what the worst coal was like. He continued to ask questions. When finally he leaned back, surfeited with figures, Dagget took a place at the table. "I wanted you to see for yourself," he said. "There really is no place where taxes other than those on

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food and lodging can be raised. If we raise the tax on coal, the people won't be able to cook and heat their homes. Taxes on clothing could be raised, I suppose, but people don't buy clothing often now, and if the cost were increased, they would simply wear their old clothing longer. That would be ruinous to weavers and tailors. The same goes for household goods. People don't replace them now any more frequently than absolutely necessary, and if the cost went up, they would contrive to use the old ones longer. If we raised the cost of feed for beasts of burden and farm animals, their owners would increase the price of the meat they sell, and wagoners would increase their prices, which would raise the cost of everything. Once—long ago—a government, not this one, placed a heavy tax on salt and the people revolted. I think no city-state in all of Nylyant has tried that since then."

"It certainly is evident that taxes make up a significant part of the city's income," Lefarn murmured. "However, it is not such a large part that we shouldn't be able to experiment in an emergency. This is an emergency. The people are already in a state of revolt. Here is what I suggest: That we suspend all taxes on food and lodging for thirty days. At the same time, we warn the people that taxes must be reinstated at the end of that time, but we will try to distribute them more equitably. This should quiet the present unrest. Of course having promised some kind of redistribution, we will have to make one."

Dagget pursed his lips and meditated. The Comptroller did the same.

"Thirty days, you say," the Comptroller mused. He looked at Dagget. "The surplus will handle it."

Dagget nodded thoughtfully. "Very well. We will suspend food and lodging taxes for thirty days with the understanding that they, or comparable taxes, will be assessed promptly at the end of the thirty day period."

The meeting ended. The Comptroller, his assistants, and Dagget took formal leave of the Yaro and his Illyar. By the time the door closed on them, Hoxton was virtually exploding with curiosity.

"Thirty days!" he exclaimed. "And what happens then? They start collecting taxes again, and the people use us for target practice! What do we gain with thirty days?"

"Ten or fifteen days more than I expected," Lefarn said. "We've bought ourselves a little extra time to find a way out of this mess." It also gave him a few more days in which to solve the riddle of Nylyant's city states, which he still thought couldn't work.

Zwaal went wild with delight when it was announced that a special coronation beer, purple in color, would be available at quarter price in all taverns as long as it lasted. The tavern owners were delighted. Hoxton was delighted to be making his public debut as Yaro under such favorable circumstances, and he managed to stand still long enough to be fitted with a ceremonial white uniform and purple robes. Lefarn selected a more modest costume for himself, a trim-looking white uniform with a purple sash.

The seamsters had to rush their work to have all the uniforms ready; the brewers had to extend themselves to color all that beer; but everything was ready in time. At dusk Hoxton and Lefarn set out with Hoxton's own two drivers on the box of his carriage. The five uniformed Bylyf brothers led the way on foot as ornamental guards, and the newly-uniformed market orchestra followed in a wagon. The women were dressed in resplendent gowns, and Lefarn had never seen six prouder musicians.

Dagget, with two unidentified assistants, insisted on accompanying them.

When they reached the first tavern, the musicians entered ahead of the Yaro and halted inside the door to shock the patrons into silence with a prolonged

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blast. Then came the acrobatic Bylyfs to perform a breathtaking three-minute exhibition. When they finished, Lefarn stopped the applause with a shout.

"His Eminence, and your new Yaro, Hoxton!"

The applause was deafening, but that was only an expression of the crowd's gratitude for the cheap beer. When Hoxton shouted his news about the thirty-day cancellation of taxes on food and lodging, the tavern's walls and roof shook. The Bylyfs were brushed aside, and Hoxton was hoisted onto shoulders and carried about the room.

Hoxton bellowed for silence. "Don't thank me," he said. "It was my Illyar, Leffi, who did it. I wouldn't have known how."

Lefarn was hoisted onto shoulders, and an exultant procession marched with them to the next tavern, where the scene was repeated—and then repeated again and again as they made a triumphant tour of all of the taverns. Everyone enjoyed it except Dagget and his assistants, who looked on worriedly.

"What's the matter with them?" Hoxton asked Lefarn.

"They're thinking about what the public reaction will be if they should decide to get rid of us," Lefarn said.

Zwaal, along with its new Yaro and Illyar, spent the night in celebration. Toward morning, Lefarn managed to slip away to his old lodging where he called the IPR CB and made a full report, describing the night's celebration and recapitulating the events that led up to it. "There is a mystery about this world that the IPR Bureau hasn't even suspected," he said. "I now have a fair shot at unraveling it. At least, I'm uniquely qualified to try."

Again the coordinator was absent, but Assistant Coordinator Raisa had been waiting to hear from him. "You are relieved of your assignment," she barked. "It's too close to daylight to pick you up now, but I'll send a platform for you tonight."

"Relieved?" Lefarn was stunned. "Why?"

"Surely you are experienced enough to have grasped something of the Bureau's mission. You have read your IPR manual, haven't you?"

IPR Field Manual 1048K contained the Gospel according to the Bureau, all of the Bureau's complex rules and regulations, punctuated with capitalized nuggets of wisdom that the IPR bureaucrats expected Bureau Trainees to memorize: "DEMOCRACY IMPOSED FROM WITHOUT IS THE SEVEREST FORM OF TYRANNY;" and "DEMOCRACY IS NOT A FORM OF GOVERNMENT; IT IS A STATE OF MIND. PEOPLE CANNOT BE ARBITRARILY PLACED IN A STATE OF MIND;" and "FUNDAMENTAL TO ANY DEMOCRACY IS THE PEOPLE'S RIGHT TO BE WRONG;" and so on and et cetera.

In idle moments, the IPR Trainees amused themselves by inventing ribald caricatures of the slogans.

"Of course I've read it," Lefarn said. The rumor that IPR trainees had to memorize the whole manual wasn't true, but no one could get through the academy without a thorough familiarity with it.

"None of it seems to have penetrated," she said acidly. "Our mission is to achieve a worldwide level ten democracy. What we have here—what we *had* here—was a world of democratic city-states. The plan was to study the situation thoroughly and then begin to slowly move those city-states toward consolidation. Eventually we would have had that worldwide democracy.

"Everything was nicely under control until you started exercising your ingenuity. In a matter of a few days, you have managed to convert one of those democratic city-states into a monarchy. In other words, you have reversed what we were trying to do. Now you tell me you are achieving a spectacular success as a king's prime minister with the result that the king—with your continued as-

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sistance—will certainly reign for life, and you've set up a model for the other cities to emulate. If that happens, you will have reversed the political situation on an entire planet and started all the governments moving in the wrong direction. Instead of working to merge the city democracies, we will first have a world of monarchies to overthrow. I have never heard of a situation such as this where one misguided agent has upset the political situation on an entire world. I'm sending you back to Sector Headquarters with the recommendation that you be expelled from the Bureau."

Lefarn dropped onto a chair and thought hard. The IPR Bureau was dead wrong about one thing. The city-states on this world were not democracies. That was what had made no sense to him when he tried to understand Zwaal. That was why the citizens were so ready to accept a popular Yaro.

What those city-states were, he did not know. He would first have to fathom the role of the Faqzwaal, which promised to be a far more difficult task than becoming prime minister to a kingdom and revamping its tax structure.

As for the Bureau's platform picking him up, it would have to find him first.

The assistant coordinator's message had jolted his own memory. He took his copy of the IPR Field Manual from its hiding place and searched for the passage he remembered. Once he found it, he read it with care before hiding the manual again.

He had a smile on his face when he caught up with Hoxton's triumphant procession. They returned to the palace, and Lefarn announced, "Tonight was fun. Tomorrow, we'll go to work."

In the morning, Lefarn summoned the Comptroller again. That august individual arrived with his teeth set for an ordeal. He looked as though he were combating an incipient case of seasickness. He did not like interrogations on financial subjects. Probably he had never experienced one before.

It was the coal that interested Lefarn. "I'm wondering what would happen if you raised the price of coal slightly—not the price to our own citizens, just the price to the more than fifty neighboring cities that buy coal from us."

"They would buy from someone else," the Comptroller said confidently.

"Do you know that for certain? Has it ever been tried?"

The Comptroller didn't know for certain, he merely assumed it because that was the way the world worked. He wouldn't dare try it. If they lost any coal business at all, they would lose a critical part of their income. They would go bankrupt. They couldn't possibly raise taxes enough to make up the deficit.

"What, exactly, do the other coal-producing cities charge for their coal?" Lefarn persisted.

The Comptroller didn't know exactly.

"Who would know? Is there someone who travels around and might have information like that?"

The Comptroller didn't know of anyone.

"I'll find someone," Lefarn said confidently. "Then we'll meet again and perhaps have something to talk about."

After the Comptroller left, Lefarn took a chair onto the balcony, made himself comfortable, and reviewed all of the oddities he had discovered about Nylyant. One of them had to contain the key to the world's puzzle. Hoxton looked out several times, watched him for a moment, and then thought better of interrupting him. As had happened before, Lefarn emerged from his reverie defeated, but he had thought of more questions to ask. He sent for the Yaro's two new drivers.

They arrived looking awkward and uncomfortable in their new uniforms. "Do we have to wear these things?" one of them demanded.

"Only when you're on duty," Lefarn told him. He described the problem. "Who would know about prices other

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cities charge for coal?"

"Maybe the drivers who haul it would know something. Want us to see what we can find out?"

"Please do. But don't wear your uniform if you go into the city."

"We wouldn't dream of it!"

They left; Lefarn returned to his meditations. The next time he emerged, he sent word that he would like to talk with Dagget if the Administrator could spare him a few minutes. Dagget appeared promptly, as oily polite and forthcoming as ever.

"I don't recall seeing an entry for salaries when I looked at the comptroller's records," he said. "Would you mind telling me what your salary is?"

"I receive no salary," Dagget said. "What would I want a salary for?"

Lefarn said slowly, "The day I arrived here, you said something about my salary . . ."

"But of course *you* have a salary. You're city. I'm Faqzwaal, so I have none."

"None of the city's administrators have a salary?"

"Certainly not."

"The Comptroller and his assistants?"

Dagget shook his head emphatically.

"The people I have hired as the Yaro's servants—the two drivers, the escorts, the musicians—"

"All city," Dagget said. "They will be paid well, of course, though not nearly as well as the Yaro and his Illyar."

"What about the driver whose place the new drivers took?"

"He is Faqzwaal so naturally he receives no salary. All those who live in the Faqzwaal and serve the city have no salary. Why would they need one? Their dwellings and everything they need are supplied to them."

"The members of the deposed Ronzwaal—"

"City, of course, so the government paid them well."

Lefarn thanked Dagget and resisted the impulse to shake his head as the Administrator departed. The more he learned about the structure of this strange city, which seemed so normal on the surface, the more confused he became and the more certain he was that it would not work.

Except that it was working.

That evening the Yaro and his Illyar made several personal appearances in taverns to keep the Yaro's popularity alive. It turned out not to be necessary—the cheap beer would last at least another day, and the people were still excited about the canceled taxes—but Hoxton enjoyed it, and the Yaro was entitled to a few small pleasures to compensate for the stress of his office.

The next morning, the Yaro's two drivers waited on Lefarn. "None of the drivers has any exact information," one of them said, "but I talked with some who haul coal from the mines to Zwaal—the coal we use ourselves. They don't handle money, no reason to, they're hauling the city's coal to the city. But at the mines they meet drivers from all of the cities buying coal from us."

"Then each city hauls the coal it buys," Lefarn suggested.

"Right. Some of the drivers come a long, long way. In fact, there are other mines much closer than ours for some of them, but their cities prefer to buy coal from us. One of the drivers I talked with had been curious about that—especially because the other driver had a long, uncomfortable trek over bad roads to get to our mines. He said his city bought coal from us because it would cost twice as much anywhere else. Also, it's better coal."

"But how would I find out exactly what coal costs elsewhere compared with what Zwaal is charging?" Lefarn asked.

The drivers had no idea.

"I must find out," Lefarn said. "Talk with those drivers again, and ask them to question drivers they meet at the mines. It is important."

After they left, Lefarn said to Hoxton,

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"Probably there isn't a single city-state, anywhere, that has a business manager."

"What's a business manager?" Hoxton wanted to know.

"That's what I would be if I knew how. It just might solve all of our problems. I'd look for one, but I'm sure there isn't a qualified person within fifty light-years of here."

"What's a light-year?" Hoxton wanted to know.

The days passed in exhausting study for Lefarn. The nights, with the Yaro keeping in touch with all of Zwaal's taverns, were even more exhausting because Lefarn worried about the things he should have accomplished during the day but hadn't. He was becoming increasingly nervous. The thirty days he'd had to solve a worldwide problem were now eighteen. And then seventeen. And then sixteen. And the clues, which had to be there, still eluded him.

One night two of the Bylyf brothers aroused him from a sound sleep to apologetically announce a crisis. They didn't trust the elderly servants who drew night duty; they had assumed responsibility for guarding the Yaro and his Illyar at all hours.

"We've caught something," one of them told Lefarn. "We suspect it of treasonous intentions, especially toward you, and the captain of the guard wants to dunk it in a cesspool and expel it from the city, but it says it knows you."

"Really? Does it have a name?" Lefarn asked.

"It calls itself Raisa."

Lefarn scrambled to his feet. "You were right to wake me. The thing is far more dangerous than it looks. It would take more than a dunking in a cesspool to neutralize it."

He went down to the palace guard room, where several of the palace guards surrounded a muffled bundle that was well-wrapped in a large tarp of the type that roofed wagons on wet days.

"Did it injure anyone?" Lefarn asked.

"It bit and scratched and kicked."

"You were lucky. It has weapons that are far more deadly than that. Bring it upstairs."

They took the bundle to his room, and while they unwrapped it, Lefarn searched each area they exposed. He found a stun gun, a communicator, and several tiny gas bombs that would have forced the evacuation of the palace.

"Wait outside," he told the Bylyfs. "But come in quickly if you hear any kind of a ruckus."

He dropped into a chair. Raisa Stantlor stood facing him, her expression one of mingled hatred and contempt. Lefarn ignored that and pondered her presence in Zwaal. She had not trained as an agent; almost certainly the Field Team Commander, whose approval was necessary before any IPR personnel left the CB, knew nothing about her headstrong action in coming here. She had been taking things into her own hands at the CB ever since she arrived. Now she had plainly overreached herself.

"Sit down," Lefarn said, remembering his last contact with her, when she lectured him for twenty minutes without offering him a chair. "The Illyar of Zwaal doesn't stand on formality like an IPR Bureau assistant coordinator."

She glared at him. Then—there was nothing else she could do other than remain standing—she sat down. She looked rather a mess after her tussle with the guards. Her clothing was rumpled and torn, her hair tousled, and she had received a few scratches herself.

At the CB, wearing the full uniform she affected there and flaunting her authority, she had been totally obnoxious. It had been difficult to think of her as female. Now—awkwardly attired in what she thought was Zwaalian female dress and just emerging from a tussle with the palace guard, she looked like something recently rescued from the police drunk and disorderly cells. He wondered how she would look if a competent Zwaalian tailor outfitted her. Perhaps almost pret-

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ty if she could control the disdainful expression she wore permanently.

There was a smear of black around her neck. "You persist in wearing that hideous necklace, no matter how inappropriate," he said testily. "For your information, Zwaalian women don't wear necklaces. They go in heavily for bangles instead." He paused. She continued to glare. "What were you trying to accomplish?" he asked her.

"I've come to arrest you and take you back to the CB to be court-martialled."

"The charge?"

"It is being drawn up now. You have violated so many regulations that it will be several pages long."

"Mmmm. That almost sounds serious." Lefarn's dry tone of voice conveyed the amusement he felt. She leaped to her feet angrily.

"Persistent and pernicious insubordination will head the list," she snapped.

"Mmmm. Sit down. Have you read your field manual lately?"

She seated herself. The glare had intensified.

"I refer specifically to the material concerning the IPR Bureau's treatment of heads of governments. Contact with them is to be avoided. No overt actions are to be taken against them. It they are overthrown, it must be by an action of their own people. No alien weapons or artifacts of any kind are to be used in that revolt, nor are the natives to be allowed knowledge that such things exist. Here you are, caught in the act of invading the residence of the prime minister of this city-state with the intention of abducting him. You were armed with enough alien weapons to change the history of technology on this planet if they had fallen into the hands of your captors. In blunt fact, you came within an eyelash of blowing the planet, in which case all of us would have had to go home. I'm not mentioning the rules you have flagrantly violated by taking to the field without proper training and without the approval of the planet's Field Team Commander. You don't even have language clearance."

"Your guards had no trouble understanding me," she said haughtily.

"The guards," Lefarn said, "were so confused by the hash you made of trying to speak Zwaalian that they had no notion of what manner of creature you might be. They referred to you as 'it.' However, you're here. Very little would be accomplished by dunking you in a cesspool and expelling you from the city, as the guards wanted to do. The question is whether you can make yourself useful. I'm working on a critically important problem—critically important to the IPR Bureau as well as to the future history of this planet—and I certainly could use some help."

She was silent for a long time.

"There is no other way out," Lefarn reminded her. "Either you go back to the CB in disgrace—I'll send an official report that not even your uncle can ignore—or you lend a hand here. Your training has been different from mine. You know about things like administration and record keeping—maybe even financial management. Stop pouting so we can consider how you can help."

"What do you want me to do?"

"First, change into something presentable. I don't know where you got the idea that the bundle of mismatched colors you are wearing constitutes women's dress in Zwaal." He rang a bell. An elderly male servant responded. Lefarn sent him for one of the women.

"This is my new assistant," he said. "She had an accident on the way here, and she needs new clothing. In fact, she needs a complete wardrobe. Can you manage something quickly? She can use the empty room next door."

One of the pleasing aspects of being Illyar was that when he asked for something, it was done with startling promptness. Raisa was gone a mere ten minutes; during that time, Lefarn gave careful instructions to the Bylyf brothers about keeping an eye on her. When she

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returned, she looked not unlike a Zwaalian woman except for her hair.

"I don't feel as though I'm fully dressed," she complained. "These things don't fit. They simply cover."

"Cover is sufficient. Tomorrow, I'll try to find time to get your hair fixed. Are you able to dress yourself, now?"

"Of course! Were you thinking you could do it?"

"If that's an offer, I respectfully decline. Male clothing still gives me enough problems. Now, since you've violated another rule by bringing a communicator with you, you will send an order to the CB telling them the charges against me are to be held in abeyance. Explain that I'm working on something vitally important to the entire IPR Bureau mission on Nylyant. After you have done that, I'll take charge of your communicator, and we can all go to bed. Tomorrow morning you will start work. A servant will wake you for breakfast, and you will have the pleasure of meeting the Yaro and his attendants."

In the morning, her expression was sourer than it had been the night before. She looked as though she still needed sleep—which probably was true since she had been up half the night trying to figure out how to break into the Yaro's palace. She was the object of intense curiosity on the part of the Yaro's attendants and especially the women of the orchestra, but she ignored their friendly overtures.

As soon as breakfast was over, Lefarn shooed everyone out except Raisa. "Work time," he announced.

The Comptroller was waiting along with his two assistants, who once more carried armloads of ledgers. Each time Lefarn sent for him, he looked more worried. He was convinced that Lefarn was giving his ledgers all that attention because he was searching for errors, and he feared that sooner or later Lefarn would find some.

"We won't need you for the rest of the morning," Lefarn told him. "Come back just before lunch. By that time we should have some questions for you."

The Comptroller left reluctantly trailing the assistants—obviously he wanted to keep an eye on the ledgers. Lefarn asked Raisa what she could make of them.

She could make nothing of them. The Zwaalian script was a total mystery to her.

Lefarn said resignedly, "I keep forgetting that you haven't been trained for field work. But you do know something about administration and finance, don't you?"

"I'm beginning to suspect that I know very little," she said. "What is it that you need?"

"I need an explanation for the city of Zwaal—how its government, and its economic and social systems, fit together."

"But you've lived here for almost a year. All I've seen are your reports. Why would you expect me to explain anything about it to you?"

"I'm hoping that a fresh viewpoint will see something I've missed. Since you can't read the ledgers, I'll tell you what I've found."

He talked, and she listened. After a time, he fancied that she was listening more attentively. Once she interrupted. "No salaries or wages paid to Faqzers working for the government, but salaries paid to City people? How do the Faqzers exist?"

"Apparently everything is free to them. There must be a market and shopkeepers in the Faqzwaal, and people simply take what they want. There's no other explanation for the wagon loads of food the city government pays for. Somewhere buried in all of these statistics, there probably are wagonloads of other things—clothing, household items, shoes—one moment, I just remembered something. I once saw two Faqzer men calling on a city goldsmith. If they bought anything, they must have had money to pay for it."

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"But their situation isn't the same as that of government employees living in the Faqzwaal," Raisa pointed out. "If they are a kind of aristocracy, of course they have money. They don't have to have a salary. There are plenty of historical examples of aristocracies that gradually lost their power and influence while at the same time remaining wealthy."

Lefarn thought for a moment. "I don't recall seeing any record of tax revenue coming from the Faqzwaal. If everything the residents want is free, of course no taxes are collected on it. If they pay no rent, there are no rents to tax. There must an explanation for all of this, but I haven't grasped it."

"Doesn't the system of government provide any clues?" Raisa asked.

"Until now, all I've had is a gwarnt's, or worms-eye, view of it. The IPR Bureau says these city-states are model democracies, but at the same time it found oddities that made it O/O the planet. I don't recall anyone explaining to me what those oddities were except that the system produces notoriously bad government. What happens is that the elections are freely held, there are always at least two slates of candidates—apparently anyone can run for office who wants to—and the incumbents are *always* booted out of office after a single term. The new officials *always* prove to be worse than the old ones, taxes are raised or new taxes added, and the process is repeated until the public becomes totally fed up and revolts—as the people of Zwaal recently did—in favor of a king. We don't know yet how that is going to turn out."

"You've painted yourself into a corner," Raisa said. "If you solve the economic problems and make the monarchy work, you have destroyed a flourishing democracy. The IPR Bureau will scalp you the moment it gets its hands on you. If you don't make the monarchy work, you and Hoxton are destined for personal appearances as targets for paving stones. What makes you think there's a way out of that?"

"I think there's got to be," Lefarn said grimly. "Back to the ledgers."

Two days later he found it—found *something*—at the rear of one of the ledgers. It was a special supplement that recorded regular payments of huge sums of money—*enormous* sums of money. "What does nymel mean?" Lefarn demanded.

Raisa had no idea.

Lefarn sent for Dagget, who knew only that it was the name of a long-standing indebtedness. Payments had been made regularly to the Nymel Fund as long as he had held office. It was an obligation; it had to be met. The city's honor and credit demanded that.

"But what *is* it?" Lefarn persisted.

The Comptroller was sent for. He spoke at length; when he finished, nothing was very clear, and the matter seemed to have little to do with Lefarn's problem except that it was another large burden on the city's financial structure; but it did explain where the Faqzwaal nobility got their money. Regular payments were made into a sort of escrow fund. The fund's money was paid out when the Faqzers, or any one of them, needed or wanted money. Further, it was paid out on demand. Unpaid funds accumulated against future need.

"All of these payments add up," Raisa observed when the Comptroller had departed. "Large ones like that add up more quickly. Zwaal has an enormous indebtedness. Where does the city get its money?"

"The gold, silver, and copper it mints coins from and sells to the gold and silversmiths comes from cities with productive mines. Zwaal probably trades coal for the amounts it needs. As for the Nymel Fund, in the early history of a lot of worlds, noblemen granted the use of land they controlled in return for service—labor, military, or whatever. Sometimes subjects were permitted to pay money instead. No doubt that is what we have here. The aristocrats once

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owned Zwaal. The city took over that ownership in exchange for regular payments, and those payments are still being made. One more riddle solved, and it proves not to mean a thing."

The only thing he knew for certain was that he had to buy more time.

One of the drivers hauling coal came to Lefarn with more information. Other cities were indeed charging more than twice as much as Zwaal, and he had the figures to prove it. Lefarn called for a conference with Dagget and the Comptroller. They reacted to that information with blank surprise. It hadn't occurred to them to compare Zwaal's prices with those of other coal-producing cities.

They refused to accept Lefarn's information. What if they raised prices and he turned out to be wrong? It wasn't until the third conference that they agreed to raise prices in stages to see how their customers reacted. The cities buying Zwaal's coal would be told that prices were not meeting production costs for some of the marginal mines, and Zwaal had to raise prices or reduce its production and eliminate some of its customers. Lefarn suggested a fifty percent raise; they compromised on twenty-five, but that would more than make up for the revenue lost from the canceled food and lodging taxes.

The thirty-day deadline was no more, and Lefarn could relax.

"Now we can stop all this tedious palaver and have fun," Hoxton said when Lefarn brought the good news.

Raisa shook her head disapprovingly. "You haven't really solved anything except to temporarily save your own neck," she told Lefarn. "There is still something drastically wrong about this world—you keep making that point, and I'm beginning to see what you mean. Raising the price of coal may solve Zwaal's tax problem, but what does it do to the budgets of the cities buying the coal? And what about cities that don't have coal to sell? What can they do about their taxes? The IPR problem isn't restricted to the city of Zwaal. It concerns all the city-states on the entire planet."

"I know a lot more questions than that," Lefarn said. "I'll have to keep studying the ledgers."

"But what if the answer isn't there?" Raisa asked.

She had been quietly industrious of late, he reflected. The Bylyfs reported that she had not even made a gesture of trying to escape or even of seeking out an escape route for future use. She was improving her knowledge of the language and learning as much as she could about life in Zwaal. The orchestra women had taught her to play an aerophone, and she took part in some of their performances. Further, she had stopped wearing her hideous necklace—as a necklace. She had shortened it in some way, or maybe doubled it, and she wore it as a wrist bangle.

She was almost cooperative when Lefarn asked her to work on something. It dawned on him finally that she expected him to fail and wanted to stay in Zwaal long enough to see him do it. She might even come to the market and watch the people of Zwaal use him for target practice. She may have been looking forward to it.

But now that date had been pushed back indefinitely by the permanent cancellation of the food and lodging taxes, leaving Lefarn to ponder the conundrum posed by the city-state of Zwaal.

The city possessed a democratic government under which the citizens freely chose their own officials. Once they chose them, it quickly developed that they didn't want them, and in the next election they always threw them out in favor of replacements that they also did not want.

The city was in hock up to its ears to an odd, retrospective aristocracy that had no function at all except to exist. The aristocracy was paid huge sums as a kind of quitrent; and at the same time the city paid for the aristocracy's food

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and anything else it needed and also supported a large staff to look after it, keep its houses repaired, feed and care for the animals it used for work and play. The aristocracy posed an enormous financial burden, and the city couldn't have met it without the large income its coal mines brought it.

At that point in his reasoning, Lefarn paused to wonder again how cities that had no mines managed. Badly, he had no doubt. Then why had the citizens of Zwaal revolted and not those of a less-favored city?

"Let's take a different approach," Raisa suggested. "You were a gwarnt. My recollection of your reports makes this a rather lowly occupation."

"It ranks both socially and economically just above, or maybe just below, that of a quabber, who cleans the city's cesspools."

"Surely your IPR training made you qualified for a number of higher positions. Why did you settle for gwarnt?"

"It was the only occupation open to me—except maybe quabber, I never investigated that. Every other occupation in the city has a guild with strict admission requirements, usually hereditary."

"Then if a goldsmith decides to relocate to Zwaal—"

"He couldn't. A goldsmith's son becomes his father's apprentice and eventually takes over the business. If he has two sons, one of them may become an apprentice to another goldsmith who has no son. Or—there seems to be an intercity connection—to a goldsmith in another city who has no son. The same applies all across the employment spectrum and even includes common laborers. They have their tight little guilds, and they accept sons of fellow laborers but not outsiders. If an actual shortage develops in a particular craft or occupation, the city will notify other cities, and the vacancies will be supplied through their guilds."

"Then if you are born in the city of Zwaal, your future is already determined. If your father is a carpenter, you will be a carpenter."

"That is correct."

"And if you, Jedd Lefarn, were a native, your son would be destined to become a gwarnt."

"You might better say 'condemned to become a gwarnt.'"

"And if your son showed tremendous talent for woodcarving—"

"If he were extremely lucky, he might attract the attention of a woodcarver who had no son, and if there are no sons of other woodcarvers available, he might be taken as an apprentice, but all of that would be highly unlikely."

"I've never heard of such a rigid society."

"Nor have I."

"The people might as well be slaves," Raisa said.

Lefarn stared at her. "They might as well be slaves." He paused. Then he said again, "They might as well be slaves. That's it. That's what I've been looking for. That's the thing that's totally wrong about these societies. They look like model democracies, but they are actually the most ingenious slave societies ever devised." He laughed excitedly, suddenly conscious of having made a stupendous discovery. "When the Bureau labeled the governments of Nylyant's cities unique in the Universe, it had no idea just how unusual they are. They are not working democracies. They are slave states, and the cities themselves are the slaveowners. It is a fiendishly contrived system in which the slaves choose their officials in free elections and think the government is a democracy that belongs to them when actually they belong to it."

The question was whether anything could be done about it.

Raisa was grappling with the implications herself. She said, "The people should realize by now that the officials are completely under the thumb of an entrenched bureaucracy. Why don't they revolt?"

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"They do. They're encouraged to. They revolt every election day. All of their indignation is cleverly focused on the government they chose themselves. And finally, when they are totally fed up, the officials neutralize their anger by letting them stone their representatives in the marketplace and give up representative government in favor of a king. And until now, the kings, or yaros, probably have governed so badly that in a short time the people revolted again and demanded a return to the supposed democratic system they recently abandoned."

He went on, speaking slowly and grappling with a flood of ideas. "While the people expend wrath and energy against governments they think they choose themselves, the bureaucracy operates virtually out of sight behind the screen provided by the elected government, and the old aristocracy, the Faqzers, also remains out of sight and continues to be the beneficiary of all this."

"I can't think the people are that stupid," Raisa said. "Sooner or later they must realize they've been had, and their indignation will spill over into a genuine revolt."

Lefarn nodded. "That's why there is such a large police force whose only duty is to control a population that doesn't seem to need it. Occasionally it is needed. The elected officials are poor, innocent, inexperienced dullards, and so charmed with their sudden high status, and high salaries, and with the palace for them and their families to live in, and with platoons of servants, that most of the time they do whatever they're asked to do, absorb the people's wrath, and bow out. It took someone with my background to ask questions and push through changes."

"Then the average citizen can only keep moving in his tight little hereditary orbit, pay his taxes, complain constantly, and vote his government out of power whenever he can," Raisa said. "So what's to be done?"

"We need a real revolution."

"A revolution against Yaro Hoxton?"

"No," Lefarn said. "A revolution that will throw out both the bureaucracy and the Faqzers." He paused. "It will be bloody. An entire social class and its appendages will have to be eliminated. But then—most revolutions the IPR Bureau engenders are bloody."

"How will you go about it?"

"By doing what I am already doing. Have you noticed that Dagget looks more worried each time we see him? I have solved all of his financial problems. Everything is running smoothly. The people are the happiest they have been in his memory. What worries him? He doesn't want a popular king. He let us suspend taxes because he thought the people would be so enraged when they were reinstituted that he could engineer a revolt against the Yaro whenever he wanted. Then, for a brief time, he was so charmed by changes that really worked that he let us abolish the taxes permanently. Now he has remembered something vital—he has to have a Yaro and an Illyar who are just as stupid as the Zwaalant and Ronzwaal members who proceeded them or he won't be able to conjure up a revolt when he really needs one. Constant change is the way he keeps the population in check. The people never have a rallying point if they are perennially dissatisfied with their government. A popular Yaro who enjoys a long reign is the last thing he wants, and Hoxton's popularity continues to grow. When Dagget gets worried enough, he will try to do something about it. We can't sit around waiting for that to happen. We'll have to be ready."

Lefarn's instinct told him no mob was going to succeed in a revolt against an overly-large and trained force of police—even one badly trained and out of condition. In a time of crisis, it was certain to have a plan to follow and tactics it hadn't displayed in Lefarn's time because they were never needed. He conferred with the Bylyf brothers, and then he sent for Dagget.

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"Zwaal has no park for its citizens' use," he said. "They need a place where they can exercise and breathe fresh air away from the city smog. Is there a meadow near the city that can be converted to a park?"

Dagget now saw sinister implications in Lefarn's most innocent request. "I don't know if that is feasible. After all, our citizens have never had a park. If they needed one, they would have asked for one long before this."

"No one has thought of it before," Lefarn said. "That's because no government has given any thought to the health and welfare of its citizens. Ask the city's employers how many days of work each year their employees lose because of illness. They get no exercise and they have nothing but smog to breathe. They need a park."

While Dagget vacillated, Lefarn inspected the possibilities, discovered an ideal plot of ground currently used to graze the Faqzers' darifs, got the darifs moved elsewhere, and had Hoxton proclaim a park. Dagget was outraged. He was even more upset when he learned that the Bylyfs were conducting organized physical fitness classes for the city's young men.

"An excellent outlet for their surplus energy," Lefarn told him. "They'll be too tired to spend their nights carousing, and their health will improve so they can give their employers a better day's work. All of the city's employers approve of the project."

In the face of such unanimity, Dagget could only beat a glowering retreat. He came to protest again when he learned that the Bylyfs' students were exercising with staves. The staves would be highly effective in the street fighting Lefarn envisioned, since the police had only short truncheons, but the calisthenics the young men practiced with them seemed innocent enough. Dagget was forced to retreat again, and the Bylyfs were left in peace to lay the foundation for a Zwaalian army.

Lefarn's next project was to reinvent the bow, which had figured largely in the ancient history of the planet but had disappeared when a worldwide system of peaceful governments developed and all need for it vanished. Lefarn reasoned that reintroducing it would not violate the IPR Bureau's stringent rule against introducing new technology to a planet—at least, if challenged, he could offer that as a plausible defense. In concealed areas in the park outside the city, the Bylyfs began training archers to shoot metal-tipped arrows at targets.

Lefarn disarmed Dagget further by aiming his next project at the health of the children. He found a lake—with a suitable sandy beach—that a gossel and wagon could reach in an hour and a half. Each day, ten wagonloads of children were hauled off to the lake for the afternoon. The government furnished the wagons, a nourishing picnic lunch, and ample supervision. The children rollicked and played and swam all day and went home to their decrepit slums, where they eagerly awaited their next turns. Dagget could hardly object to improving the health of Zwaal's children. The Yaro's popularity, already at an astronomical high, received another massive boost, and Dagget's countenance took on another veneer of gloom.

Sooner or later, and probably sooner, Dagget would feel that he had to take some kind of counteraction. In the meantime, Lefarn made his own use of the children's expeditions. The project enabled him to form a private corps of agents who were also wagon drivers. No one was inspecting the children as they loaded up, or noticing if ten wagonloads of children occupied twelve wagons on the way out and only ten on the way back; or that on some days, the twelve increased to fourteen for the return journey. This enabled extra drivers to slip away from the children's day camp each day and, riding darifs that had been used to pull the wagons, head for a distant city, leaving the extra wag-

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ons behind at the day camp to be picked up on their return. In this way, the fame of Zwaal's new Yaro and the amazing things he was doing for his people was spread through a host of cities, and he was already a legend when rumors finally began to trickle back to Dagget and the Zwaalian bureaucracy.

While these projects were progressing, Lefarn was improving his knowledge of geography. First came the geography of the city of Zwaal. One of the Bylyfs made a passing reference to a tunnel; Lefarn pounced on it. Yes, there were several tunnels, the Bylyf said offhandedly. That was how farmers smuggled some of their produce and grain into the city to avoid taxes. Those who knew about them preserved the secret valiantly. Their existence lowered the price of food. When Lefarn got taxes on retail sales of food abolished, taxes on food brought into the city had not been included. The city had been taxing everything several times, and it took patience to sort it all out.

Those guarding the tunnel secret knew the Illyar was on their side, and Lefarn had no difficulty in obtaining permission to inspect the tunnels. They were real tunnels, stone-lined and probably centuries old, each with an opening in a stable or basement of a house on the city side of the wall, and an outside opening in one of the cluster of stables and storage buildings that huddled on the outside of the city wall. Probably their presence was inevitable. Lefarn's question was how he could make use of them.

There were two city gates plus the Faqzers' private gate. All were ceremoniously locked shortly after sunset and unlocked shortly before sunrise. The tunnels added a new dimension to Lefarn's plotting. He easily could buy some riding darifs and train patrols to operate outside the city's walls—but what could a patrol accomplish? He stood on his balcony after dark, staring into the gloom of the country between the city and the ring of mountains that surrounded it, and meditating on the fact that nothing moved out there until early morning when farmers took to the sketchy roads with wagons of produce for the city. They were lined up and waiting when the city's gates opened.

Then he asked himself how he knew nothing moved out there. There were no travelers. Because there was nowhere to stop, those with business in the city timed their journeys to arrive during the day when the gates were open. Perhaps it was time he found out what went on at night. He instructed the Bylyfs to buy the darifs, stable them outside the city near the tunnel exits, and find and train patrol riders.

Everything was proceeding smoothly—so smoothly that plotting a revolution began to seem rather a lark. Even Raisa was ready. The days of study had bored her, but the notion of a people fighting for their freedom had an irresistible attraction. She persuaded the Bylyfs to take her to the park and let her shoot a few arrows, and she demonstrated a quick eye and excellent coordination. She wanted to organize a company of women archers, but "equal rights for women" was not yet a cause that Lefarn was willing to espouse. The men might have objected. "One revolution at a time," he said, "which would make another excellent slogan for Field Manual 1048K."

Lefarn was continuing to search for factors that made Nylyant's unworkable cities work. He reasoned that on a planet of slave cities, all-out, violent revolutions must have happened in the past. Perhaps on a planetwide basis they happened with some frequency. Obviously they'd had no more than temporary success. Behind the ingenious form of slavery that was practiced in all of the cities, there had to be an arrangement by which other cities came to the assistance of one whose citizens revolted. Help would be provided by the inflated police forces of the neighboring cities

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but not by their enslaved citizens, who would be carefully kept uninformed.

Once he divined the necessity for city-to-city police assistance, he wondered whether other forms of assistance would be feasible. These might even include economic assistance for cities that lacked an extra resource like Zwaal's coal. It would explain how a city without resources remained economically afloat. The more prosperous cities were financing the Faqzers of the poor cities. The world of Nylyant was a world of slave states supporting a socialized nobility.

The riddle of Nylyant's inexplicable city-state democracies was finally becoming understandable.

Attendance at the Bylyfs' classes in the park was still growing. Even old Hoxton, who hated exercise like a plague, joined them occasionally and imposed an unnatural strain on his muscles by way of showing his approval. Lefarn was now watching and waiting.

He was awakened in the middle of the night to deal with an odd sort of crisis. One of his night patrols had happened onto something it had never sighted before—a well-escorted wagon leaving the city. The patrol commander had sent several of his men to find the other two patrols that were on duty; he followed the wagon—very quietly, at a distance. When the three patrols were assembled, they attacked suddenly, out of the darkness, and captured wagon and escort. Now they wanted to know what to do with it.

"What's in the wagon?" Lefarn wanted to know.

"Gold," the Bylyf brother said. "That's no problem. We can bring it back to the city through one of the tunnels and hide it. But what do we do with the escort? There are fourteen police officers plus the wagon driver. The easiest thing would be to turn them loose."

"We can't do that," Lefarn said. "They would return to the city at top speed and tell the Administrator what happened. If we can keep him from knowing, perhaps he'll send another load tonight."

The captives were taken to a remote farm and held there under guard. The gold, which had been cast in short rods—probably these were easier to handle than bars would have been—was hidden in the lower city.

The next night there was another wagon. Lefarn dealt with it the same way, shaking his head. He wondered how much of a hoard the Zwaal Faqzers had accumulated through their long exploitation of their people.

The next night there was a third. The captives were now numerous enough to become a severe inconvenience. Lefarn began to wish something would happen to take his problems out of the petty nuisance class.

Finally Dagget acted. He announced that a fire in another city had destroyed its breweries. For a time, Zwaal would have to share its beer with that city.

It was a mild enough beginning. The daily allotment of beer was decreased, which affected only the heavy drinkers. There was still a moderate amount for everyone.

Lefarn quickly learned that there had been no fire. Further, no shipments of beer were being made. Beer was simply being hauled away to storage buildings Lefarn had not known about—probably they contained all manner of surpluses stored for use in future emergencies. Then the allotment of beer was decreased again. Now beer was genuinely in short supply and had to be rationed in Zwaal.

Next Dagget closed the taverns, thereby eliminating the rallying places for the Yaro's popularity. Lefarn watched approvingly and arranged for his corps of wagon drivers to begin bringing loads of staves, bows, and arrows into the city disguised as loads of wood.

On the third night, a peaceful torch procession ended at the Yaro's palace, and a committee presented a petition

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for the reopening of the taverns. Dagget asked Hoxton to address the crowd.

"What would I say?" Hoxton wanted to know.

"You should apologize for the inconvenience caused to our citizens by a neighboring city's fire and promise that the taverns will reopen shortly."

"I don't know anything about any of those things," Hoxton said. "You closed the taverns; you make the announcement."

Dagget did so with his usual oily suaveness. There were angry mutters, but the crowd eventually dispersed.

Lefarn was ready. The people were ready—they were now staging daily protest marches to the government square before the palace. The weapons were ready. Raisa was ready. She was, in fact, tired of waiting.

"Lock her up, or she'll start a revolution all by herself," one of the Bylyfs complained to Lefarn. "She wants to shoot someone. If you aren't careful, she may shoot you."

A spark was all that was needed, and Lefarn waited for Dagget to supply it.

"I think," Lefarn told him the next evening, when he visited the Palace to look down on a square filled with protesters, "you'd better reopen the taverns at once, or neither you nor the Yaro will be able to control the crowds."

"But what can we do if there is no beer?" Dagget asked innocently.

Lefarn's own agents had been spreading the word, and the majority of the citizens knew perfectly well that there was plenty of beer. "Whether there is beer or not, the citizens think there is," Lefarn said. "In which case you had better produce some."

"I can do much better than that," Dagget said. "I can eliminate you and the Yaro and control the crowds in my own way."

Suddenly the palace was filled with police officers, who bundled Hoxton, Lefarn, the Bylyfs, Raisa, and any other supporters whose personal loyalty belonged to the Yaro, through a concealed passageway to the basement of Police Headquarters, where they were packed into cells.

Lefarn started a roll call to learn who was present. All of his key subordinates been captured. Even the women of the orchestra had been crowded into cells with them.

He was reminded too late that creating a successful revolution required skill and experience—and the ability to think ahead of one's opponents. His supporters outside were poised to take over the city when he gave the word, but they had no direction, they didn't know where the weapons were, and they would have no idea what had happened to the Yaro and his Illyar. They wouldn't do anything until they heard from him. He experienced the despair of total helplessness.

He examined the lock on his cell with care and received a surprise. He had never seen a Nylyantian lock before, but he would have expected locks in such a technologically naive society to succumb quickly to a superior education such as his. These locks were unbelievably complicated. He borrowed odds and ends from his cell mates to try to contrive a lock pick. Nothing worked.

The Bylyfs were arguing bitterly over whose fault it had been. "Never mind that," Lefarn called to them. "All of us were overconfident, and that was my fault. Try and think of some way to get us out. I haven't been able to make anything of these locks."

Raisa spoke from two cells further down the row. "A society develops technologically along the lines that interest it most. Obviously our captors have an acute interest in keeping people in jail. As for getting out—where would you go if you did? We've lost our home. We've lost our jobs, and that includes the right to eat regularly. Very shortly, we will begin to really appreciate those palace cooks."

"All of these government buildings

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must be connected," Lefarn said. "If they could bring us here from the Palace, surely we can find our way back to the Palace. If we can't, we can go upstairs and take over Police Headquarters."

"All right," Raisa said. "Let's do that."

There was a clanking sound. "These are rather primitive locks," she announced. "The keys are a bit complicated, but the locks are rather primitive." She stepped into the cramped corridor and went to work on the next lock.

"How are you doing that?" Lefarn demanded.

"The 'how' is complicated. You wouldn't understand if your education didn't include—"

"Stop that! How are you doing it?"

"With that necklace of mine you think is so hideous. It's actually a whole tool kit. My mother told me a girl should never leave home without one."

She quickly opened all of the cells. Lefarn conferred with the Bylyfs and decided to take over the Police Headquarters first. They surged up the stairs—and found the place virtually deserted. The square outside was packed with protesting humanity, and almost every police officer in Zwaal was guarding the Palace, where Dagget was, or blocking streets around the Palace Square in an effort to control the crowd's movements.

As soon as the situation became clear, Lefarn's force positioned itself on the edge of the crowd and watched.

Dagget was a shrewd psychologist. At least, he considered himself one. He was waiting for the crowd's mood to reach the precise degree of anger that he required. Then he boldly stepped onto a balcony and addressed it.

"Your Yaro has so mismanaged things that you've lost your beer!" he proclaimed. "Do you want a new Yaro?"

The roar of approval he expected did not come. The crowd was sullenly silent. Suddenly all of its attention was directed at one side of the square, where the Bylyfs had hoisted Hoxton to their shoulders. "You stole the beer yourself, you scoundrel!" Hoxton bellowed. "Now you've stolen the Yaro's Palace."

The roar of the crowd was accompanied by paving stones. A bloodied Dagget was carried inside. A surging crowd, led by the Bylyfs, crashed through the Palace doors. Dagget was captured, along with his police escort, and the revolution was on.

By that time the entire city was revolting. The police, once they grasped that fact, began to join Lefarn's forces. Their homes and families were there, and they were unanimously for a peaceful resolution. The revolt became a triumphant procession.

"Just think," Lefarn told Raisa. "You did it all with that ugly necklace of yours."

When they broke into the Faqzwaal, they found it deserted. The Faqzers had sensed the growing mood of anger in the city. Probably night after night, in groups too small to attract notice, they had been leaving the city by way of their private avenue. Lefarn's patrols had missed the quick-moving riders but had the good luck to intercept the slower-moving gold. Lefarn immediately organized a search to see whether the Faqzers had left hidden treasures behind.

"They're planning to return when the police have restored order," he said. "If the police can't restore order, then their Plan Two will go into effect."

"What is Plan Two?" Raisa wanted to know.

"I have no idea, but we'll find out shortly. I think it will mean war."

He sent out far-ranging scouts, and they soon reported that police from all the surrounding cities were marching on Zwaal. Lefarn ignored them while he addressed himself to more immediate problems. He held the fate of the city's bureaucracy in his hands. He made a quick executive decision: He slapped the high bureaucracy into the police jail cells. Those actually involved with run-

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ning the city and keeping its records he considered valuable. He kept them in their jobs. Those concerned with toadying to the Faqzers and keeping the population in check were assigned to street cleaning. The police were inducted into his army, given command assignments, and set to training the citizens.

He sent out all of his special agents—drivers who already knew the surrounding cities well. Riding the fastest darifs the city could offer, they were to slip through and around the encircling army of police and do what they could about inciting uprisings in the cities the police had left.

"You're taking on too much," was Raisa's observation.

"Unfortunately," Lefarn said, "it isn't possible to start just part of a revolution. That would make another good slogan for the IPR Field Manual. One must have all of a revolution or none. Also, when the time is ripe for a revolution, one can't indulge in the luxury of postponing it until one feels better prepared."

As the army of police slowly surrounded the city, Lefarn scrutinized it critically from the city wall. It was a ragged-looking army. Since the police had little to do, many cities had neglected them. Uniforms looked frayed and faded. The bloat of habitual drunkenness had blighted the ranks. There was an air of improvisation about the formations—here, a mere scattering of troops; there, tidy ranks; elsewhere, a disorganized mob. There seemed to be no high command.

Centuries of a system of slavery the people hadn't recognized had severely blighted the discipline and physical condition of the police. There was a mien of nonchalance about them. They were accustomed to trivial uprisings that could be handled with threatening gestures of their ridiculous truncheons. They wouldn't know what to do when the revolt proved to be a genuine uprising and their waving truncheons struck no fear into men who'd been trained and armed and who had got the idea they were fighting for their freedom.

Lefarn searched the ragged ranks for clues to the tactics he might expect. The one thing that might quickly leave his force helpless would be a siege. Otherwise, he was curious as to how the police would cope with the problem of attacking a walled city. He looked for rock-throwing machines that would batter breaches in the walls, and for digging tools that could be used to prepare entrenchments that would give the police protected routes close to the walls. There were none. The police encircled the city, moving about aimlessly, shifting their strength here and there as though getting ready for a parade.

Finally, when their leaders decided to charge the city walls and scale them, they produced ladders, but the ladders seemed flimsy and far too few. With yips and yells the lines surged forward—to the delight of Lefarn's archers, who were positioned on the ramparts and waiting eagerly to test their marksmanship. The massed ranks charging at them could hardly be missed, and the first flight of arrows brought the war to a halt. It was so totally unexpected and so overwhelmingly effective that the police, who seemed to have thought they could subdue the rebels without experiencing any casualties at all, were horrified to see their front ranks suddenly mowed down.

They took to their heels. The entire army, which numbered several thousand, simply faded away. Their leaders, watching from safe distances, tried to rally them, but the police did not waver. They were headed for the surrounding mountains at the best pace they could manage, and they kept going. They had covered several miles before the leaders established some semblance of order. Then, to Lefarn's amazement, they marched their army out of sight at a forced pace.

"I wonder," Lefarn mused, "if they have had word of uprisings at home."

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"What happens next?" Raisa asked. The two of them stood on the city wall straining their eyes to follow the flight of the police armies.

"Maybe they'll be back and there'll be more battles to fight," Lefarn said. "Somehow I don't think so, though. They don't know anything about the bow, and the arrows seemed like a terrifying weapon to them. So maybe it really is over, and when we march our archers to other cities they'll succumb easily. It gives us another slogan for Field Manual 1048K. The more complicated the problem, the simpler the solution. Now we can concentrate on giving the city—all of the cities—efficient administrations and genuine democracies."

"You're going to throw out your pal Hoxton?"

"Hoxton is ready to abdicate whenever I give him the word. He's had a great time, but he's also had enough. His health is poor, and he is beginning to think he had more fun when he was entertaining kids in the market and had no stupid ceremonies to dress up for. It will seem natural for him to happily pass along his title and responsibilities to me. We've had a father/son relationship for almost a year. After that, there will be more hard work, because no one here really understands what a democracy is or knows anything about an efficiently administered government, but as soon as properly elected officials are ready for it, I will transfer my power to them. Keeping things moving in the other cities will be the problem. The revolts will stumble until strong leadership emerges. Then they should flow across the continent in waves. What are you smiling about?"

"It's all been so easy, and you think it will go right on being easy. For one thing, I don't think you can conquer a world with bows and arrows without the other side catching on and developing its own companies of archers."

"They may, of course," Lefarn agreed. "Someone among the troops we just defeated may be working on that right now. But whatever they do, we will be far ahead of them."

Raisa laughed outright. "You have your plans arranged so smugly, and they don't mean a thing. There's a message from the CB. The Sector Supervisor has arrived, and you are ordered to report to him immediately. He's sending a platform tonight, and he wants you to suggest a safe place to pick you up." She paused. "I'm ordered to the CB, also. Probably he will sack both of us and return us to civilian life. It's a pity. I was just beginning to enjoy the IPR Bureau. I like field work. It can be fun once one gets away from headquarters and all the rules and regulations."

Sector Supervisor Bron Wilkor looked surprisingly young and unexpectedly congenial. He unfolded his lank form behind what had been Coordinator Stantlor's desk and reached across to shake hands with Lefarn.

"Sorry to pull you in at such a critical moment, but I must know what is happening," he said. "I have no doubt that you are right—the alleged democracies are really an ingenious form of slavery, and it may be unique in the galaxy. I certainly have never heard of a situation where the slaves didn't know they were slaves but thought they were choosing their own government in regular elections. One reason we were so slow in finding that out is the total disorganization here at the CB. The coordinator is senile; the assistant coordinator is inexperienced and poorly qualified for any kind of an administrative post—a shocking example of nepotism where none is supposed to exist. I'm firing the whole base staff and bringing in a new coordinator. Now sit down and tell me exactly what has happened and why."

Lefarn talked. And talked. The Sector Supervisor listened. He interrupted only once. "When Assistant-Coordinator Stantlor tried to intervene, did she cause you any difficulties?"

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"No, sir. Once she grasped what I was trying to do, she became most helpful."

"Really? From the reports I have on her, that doesn't seem possible."

Lefarn finally finished, and both men leaned back wearily. Lefarn was feeling greatly relieved. His dubious reinvention of the bow and arrow had slipped past without even a questioning frown.

"Very well," the Sector Supervisor said. "You've handled a totally new situation very capably—brilliantly, in fact—and you did it with no help at all from your superiors. The problem we face now is one of taking advantage of what you have achieved. I'm reorganizing the planet. I'm appointing three new assistants to the Field Team Commander, one for each continent. You will be one of them. Right now your continent is where the action is, and we need to build your team as quickly as possible—no small problem since you'll be doing it with a revolution in progress. I'll give you any agent on Nylyant that you ask for by name and bring in experienced agents from other planets as fast as they become available."

"Yes, sir. Just to start with, I'd like to have Assistant-Coordinator Stantlor, sir."

"No. That you can't have. I have never seen such an accumulation of negatives concerning one administrator."

"That may be true, sir, but she won't be administrating anything. The simple truth is that right now she is the only IPR-trained person on Nylyant, other than myself, who knows what is going on, and she has been doing good field work. I couldn't have brought this off without her. Also, she has a necklace that I think should be made standard equipment for all female agents. Maybe male agents, too."

The sector supervisor gave him a puzzled frown. Then he laughed. "All right. As long as you promise to keep Stantlor away from the CB or any other headquarters. There is one more thing. How would you summarize the Nylyant problem and your solution of it? We need something we can pass along to agents working on other worlds. It is important that the IPR Bureau doesn't have to learn the same thing twice."

Lefarn nodded wisely. He had heard from other agents that the IPR Bureau ended every successful field operation with a quest for more nuggets of presumed wisdom that could be displayed in its fabled field manual like insects trapped in amber—something like DEMOCRACY IS NOT A FORM OF GOVERNMENT; IT IS A STATE OF MIND, and all the rest.

"I'm afraid the Nylyant lesson is much too complicated for that," Lefarn said. "This world presented us with a remarkable display of democracies that weren't, and I never would have figured them out without the accidental presence of a king who wasn't." ■

(EDITOR'S NOTE: The Interplanetary Relations Bureau also appeared in the novels *The Still, Small Voice of Trumpets* and *The World Menders*, the first versions of which appeared in *Analog* in 1961 and 1971.)

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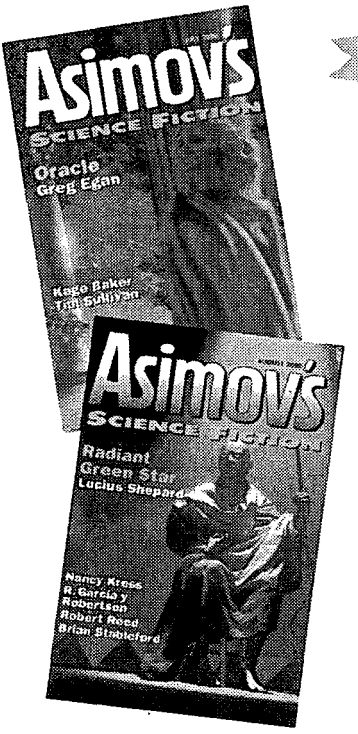

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Recent experiments may not have the implications we'd hoped for, but they may . . .

When Light Speed Isn't Fast Enough: Creating Superluminal Supercomputers

Dr. Casimer DeCusatis

"In theory, there is no difference between theory and practice, but in practice there is." - computer scientist Jan L. A. van de Snepscheut

"If I had only known, I would have been a locksmith." - Albert Einstein

When most Analog readers think of exceeding the speed of light, it's usually in the context of traveling to distant stars. Likewise, faster-than-light communication conjures up images of causality violation, or sending yourself an e-mail with tomorrow's winning lottery numbers. It's true that conventional physics wisdom implies that nothing can be accelerated to exceed the speed of light (theoretical particles like tachyons are permitted to travel faster than light as long as they never slow down below light speed). However, some groundbreaking recent experiments[1] have turned that wisdom on its head by demonstrating that it *is* possible to make a pulse of light travel faster than it would in vacuum, effectively exceeding its own speed limit. Don't start drawing up blueprints for that time machine just yet, though; even though these experiments in superluminal propagation aren't completely understood, it's generally acknowledged that they don't violate causality. Even so, this early work holds the promise for not only giving us new insights into how nature works, but also for opening up new applications to many practical engineering problems. In particular, I'd like to talk about some of the implications for computer systems. Vast improvements can be made to existing computers if we have the means to overcome light speed; this may be a brute force approach, but it could yield answers to many of the so-called "Grand

[1] See John G. Cramer's Alternate View column for March 2001, "Faster-than-Light Pulses?"

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Challenge" problems that currently resist our biggest supercomputers. Even more exciting are the prospects for an entirely new class of quantum computer, orders of magnitude more powerful than anything even conceived of today. From deciphering the secrets of protein folding in large molecules to modeling the creation of the Universe, these superluminal supercomputers promise innovations that could literally change every aspect of our way of life—but first, let's back up a few steps and look at what really came out of the labs at NEC Corporation in Princeton, New Jersey last summer.

Faster than a Speeding Photon

The principle that no moving object, or signal such as a radio wave, can travel faster than the speed of light in a vacuum has long been accepted as one of the fundamental rules of the Universe. Einstein's theory of special relativity and the principle of causality imply that the Universe has an upper speed limit of c, 3×10^8 meters/second (about 186,000 miles per second). Nothing can travel faster than c, not even pulses of light itself. Therefore, faster-than-light communication should be impossible. Yet, despite the unequivocal acceptance of this principle by scientists worldwide, there is no formal mathematical proof that electromagnetic wave packets such as microwave or light pulses must always travel slower than the universal speed limit. One might expect that such a proof could be derived from Maxwell's equations, which have proven to be a very successful model for all types of electromagnetic wave propagation; yet, the absence of such a proof has cast enough of a shadow of doubt that some scientists question whether this principle holds true in all circumstances. There is general agreement that nothing macroscopic with mass (such as a space ship) can travel faster than light; however, the question of whether a packet of waves can be considered to be a "signal" subject to the same constraints is much more complicated and difficult to answer. In fact, the notion of faster-than-light propagation isn't as heretical as it first seems; a number of experiments have shown optical and microwave pulses which appear to travel about 1.7 times c over very short distances (comparable to the wavelength of the radiation itself).

It's a well-known principle of physics that you can create a pulsed signal (finite duration in time) by adding up an infinite number of waves with different frequencies. The shorter the desired pulse, the larger the bandwidth of frequencies that must be used. All pulses of light or microwaves are thus formed by a packet of waves, each of which has a different frequency, amplitude, and phase. There is a distinction between the speeds of the individual frequency components, called the phase velocity, and the speed at which the wave packet propagates, called the group velocity. Conventional physics allows the phase velocity to exceed the speed of light, although the group velocity (the speed at which information is actually conveyed) must be less than c. It's possible to have a medium in which the phase and group velocities are not only different, but in opposite directions (one positive, the other negative). While the idea of some wave components moving backward while the wave packet only moves forward is nonintuitive, these so-called backward-propagating modes are not new, and have been observed under many circumstances. Imagine a pocket of congestion on a highway, which can propagate back from a toll booth as rush hour begins, even though all the cars are still moving forward.

To design a medium in which faster-than-c propagation is possible, you need to have a negative group velocity or so-called anomalous dispersion.[2] It turns out that there are some materials which exhibit negative group velocities, typically near an atomic absorption frequen-

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cy; in theory, light propagating through such a region should be able to travel faster than c. Unfortunately, this region also corresponds to very high optical attenuation and nonlinearities, which have made many prior experiments tantalizingly inconclusive. While some wave packets did appear to be traveling faster than light, the resulting pulses were either very weak or had their shapes badly distorted in the process, making interpretations of these results controversial at best. Then, in May of 2000, Mugnai *et al.*, working in Firenze, Italy, observed good evidence of microwave pulses traveling about 7% faster than c over distances of about 1 meter—about ten times the wavelength of the radiation itself (ref. 1).

Following close on the heels of this discovery came an article in the July 20 issue of *Nature* by Wang *et al.*, of NEC Research in Princeton, New Jersey, demonstrating superluminal propagation of optical signals, again over distances much larger than the wavelength of light (ref 2-4). To avoid distortions in the optical pulse which had confused the results of previous experiments, they used a slightly different approach. Working with a medium where there is gain, or optical amplification, near the region of negative group velocity, they launched a narrow optical pulse (3.7 microseconds) into a chamber 6 cm long that was filled with excited atomic cesium vapor. If the chamber had been filled with vacuum, the optical pulse should have taken about 0.02 nanoseconds to pass through; instead, the leading edge of the optical pulse appeared at the chamber's exit 62 nanoseconds before the bulk of the pulse entered the chamber. In other words, the wave packet had traveled nearly 20 meters away from the chamber exit before the incoming pulse entered. The optical pulse was shifted forward in time by about 1.7 % of its width, giving a group velocity inside the chamber of about—c/330. The optical pulse emerging from the chamber was identical in shape to the one which entered.

The mechanism for this is not completely understood, although it does not appear to violate the causality principle. It's true that the peak of the pulse exits the chamber before the peak of the incident laser pulse enters the chamber. However, the leading edge of the incident pulse has all the information necessary to reconstruct the peak of the output pulse, so the entire pulse does not need to enter the chamber before it exists at the opposite side. The output pulse may be just a clever interference effect, shaping newly created photons from the gain region into an exact copy of the incident light pulse. The original incoming pulse is subsequently canceled out by a backward-propagating mode that travels from the chamber exit to its entrance with a phase velocity about 330 times faster than c.

The net effect is to make the chamber appear shorter than it really is. Imagine trying to measure the chamber's length by placing optical detectors at the chamber entrance and exit. When the half-peak intensity of the incident pulse enters the chamber, you start a clock. When the half-peak intensity of the pulse exits the chamber, you stop the clock. Then you subtract the two times

[2] The generally accepted definition of normal dispersion is when long wavelengths have a higher group velocity than short wavelengths; if a wide spectrum of light is launched into a medium with normal dispersion, the red wavelengths will emerge first, followed by the blue wavelengths. For anomalous dispersion, the situation is reversed; short wavelengths travel faster than long wavelengths, and blue light will emerge from the medium before red light. Some engineering texts reverse these definitions, so use caution when consulting reference materials.

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to compute how long it took for a pulse to travel the length of the chamber; assuming conventional subluminal speed, you would think the chamber was only 1.8 cm long, or an apparent length contraction of 330%. The group velocity of the light pulse (the speed at which the half peak intensity point on the rising edge of the waveform travels) is clearly faster than c in this experiment, leading some people to wonder whether a train of such pulses being measured at their half-peak points could convey digital data. However, some scientists argue that the true speed at which information is carried by a light pulse is not the group velocity of a smooth pulse, but rather the speed at which a sudden step-like discontinuity in the waveform travels. According to the theory behind the NEC experiment, an abrupt discontinuity in the light pulse would not be able to travel faster than c using this approach. Others claim that the photons emerging from the chamber may not be the same ones that entered it, so the speed of light may not have been broken in a strict sense. The true speed at which information is carried by an optical pulse is a matter of ongoing debate, but most researchers seem to feel that even though the effect appears to precede the cause, you still can't transmit useful information (such as warning of an impending stock market crash) backward in time.

Changing the Face of Computing

Even if faster-than-light signal propagation doesn't allow you to send messages into the past, it still offers the potential to change the future with exciting new applications in computer technology. Aside from an altruistic interest in basic research, you may wonder why a computer company like NEC would be interested in faster-than-light physics. One reason is that fiber optics has become an integral part of both the networks which connect computers to storage devices and the internal interconnection among processors in very large parallel computer architectures. For example, let's consider the use of fiber optics in mainframe computer systems.

By some estimates, mainframes contain about 70% of the world's data; these computers run all the mission-critical software applications at large banks, airlines, credit card companies, and other Fortune 1000 businesses, as well as many governments, universities, libraries, NASA, and even things like the Olympics and the Red Cross. Mainframe computers typically manage huge databases of information; a big commercial user today might have several petabytes (10^{15} bytes) of data stored on various media including magnetic tape and magnetic or optical disk drives. Prior to 1990, a mainframe was connected to its storage devices mostly with thick copper cables about 400 feet (120 meters) long; all of the storage was huddled close together in a "glass house" around the computer.

Now, everyone knows that you need to keep backup copies of critical data; this was done using an approach commonly called PTAM—Pickup Truck Access Method. Every night, boxes of tapes and disks were loaded onto trucks and driven to another computer center, where they could be loaded by hand onto new drives and readers. Ideally, the remote location would be far enough away from the main location to keep a copy of the data safely stored in case an earthquake, power failure, or other disaster struck the mainframe. The problem with this approach, in addition to being time-consuming and expensive, was that you could only perform this level of backup once a day at most. In the event of a disaster, you would lose all the data since your last backup copy (assuming the truck didn't have an accident in the few hours it took to drive to the backup location).

Some mainframes are located near flood plains and earthquake fault lines,

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or have other considerations that made long-distance backup necessary despite the difficulties involved. But as computers became faster and applications became more complex, it was no longer acceptable to take the chance of losing a full day's worth of data; some method was needed to reliably send large amounts of data over long distances at more frequent intervals. Telephone lines weren't a viable solution to the problem; even a fast 56-kilobit modem running at full speed would take over 13 years to download a measly terabyte of data, and copper phone lines lacked the bandwidth necessary to significantly increase the data rate. Instead, optical fiber data links were introduced with the capacity to transfer much larger chunks of data at higher speeds. By the mid-'90s most mainframes were being connected to remote storage devices housed tens of kilometers away. This fundamentally changed the way in which most people planned their computer centers, and the amount of data they could safely process; it also led many industry pundits to declare "the death of distance".

Unfortunately, things weren't that simple; getting signals out to longer distances was only part of the answer. Unlike relatively low-bandwidth telephone signals, performance of many data communication protocols begins to suffer with increasing latency (the time delay incurred to complete transfer of data from storage to the processor). Let's say that you want to connect a computer in New York with data stored in San Francisco. You can't move the two cities closer together, so you still need to wait for the signals to get there and back again (about 42 milliseconds round-trip latency if you traveled in a straight line without stopping, longer for a more realistic route). Distance may be dead, but latency is immortal, and it can significantly slow down a large computer system. Further compounding the problem, many data communication protocols were never designed to work efficiently over long distances. They required the computer to send overhead messages to perform functions such as initializing the communication path, verifying it was secure, and confirming error-free transmission for every byte of data. This meant that perhaps a half-dozen control messages had to pass back and forth between the computer and storage unit for every block of data, while the computer processor sat idle waiting for something to process.

As an example, consider a typical fiber optic link with a latency of about 10 microseconds per kilometer round trip. A mainframe available in 1995 capable of executing 500 million instructions per second (MIPS) needs to wait for not only the data to arrive, but also for 6 or more handshakes of the overhead protocols to make the round trip from the computer to the storage devices. The computer could be wasting 100 MIPS of work, or 20% of its maximum capacity, while it waited for data to be retrieved from a remote location 20 kilometers away.

The effect became known as "performance droop"; a data link capable of, say, 20 megabytes per second throughput at short distances might degrade to less than half that at 20-km, and decrease by more than half again at 40 km. Although there are other contributing factors, such as the software applications and workload, this problem generally becomes worse as computers get faster, because more and more processor cycles are wasted waiting for the data. By the late '90s mainframes were introduced with a capacity of 1000 MIPS, which effectively could be reduced to only 800 MIPS when running the same 20 km link described earlier. In other words, with a slow processor you may not be getting work done during the latency period, but with a fast processor you aren't getting even more work done—you're wasting more processor cycles in the same period of time.

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As this became a serious problem, various efforts were made to design lower-latency communication links. For example, new protocols were introduced which required fewer handshakes to transfer data efficiently, and the raw bandwidth of the fiber optic links was increased from 20 megabytes to nearly 100 megabytes so that there would still be enough usable channel capacity left over after incurring the latency penalty. Much progress has been made in this area, and more remains to be done—but today there are still many applications that require much longer distances than what can be achieved with the best available designs. For very long-distance applications, the latency of signals in the optical fiber remains a fundamental limitation, set by the speed of light. This is one of the few ways in which special relativity directly affects our daily lives.

Or is it? The NEC experiments suggest for the first time that it may be possible to build an optical waveguide which carries signals faster than the speed of light, making a 6-cm tube seem as if it were only 1.8 cm long. In other words, the effect of superluminal propagation is to reduce the effective latency; the round trip from New York to San Francisco would take only about 12.7 milliseconds in a cesium-filled waveguide. This translates directly into better performance for existing computer processors. Granted, we're a long way from having such waveguides in use, but it's been shown that people are willing to invest a lot of money in developing faster computer technologies; the potential benefits of engineering a superluminal waveguide could make it a worthwhile pursuit. Besides, now that we've shown it's possible to send light (or at least some aspect of it) 300 times faster than c, who's to say we can't engineer other materials that may be 500 or 1,000 times faster than c, with proportionally greater increases in computer performance?

In fact, latency is not only a problem for processor to storage interconnections, but also a fundamental limit in the internal design of very large computer systems. A common approach to building very powerful processors is to take a lot of smaller processors and interconnect them in parallel. In some cases, you can split up a problem into many smaller parts, distribute them to the smaller processors, and then recombine the results as they are completed to form the final answer. This is called asynchronous processing, and there are many problems which fall into this classification. One of the best examples is SETI@home, free software you can download to your home personal computer that uses spare processing power to analyze extraterrestrial signals from the Arecibo Radio Telescope, searching for signs of intelligent life. There are currently over 1.6 million SETI@home subscribers in 224 countries, averaging 10 teraflops (10 trillion floating point operations performed per second) and having contributed the equivalent of over 165,000 years of computer time to the project. Taken together, this is arguably the world's largest distributed supercomputer—and it's mostly interconnected with optical fiber via the Internet backbone.

However, the real advantage to reducing latency comes from those problems which can't be so easily partitioned into smaller chunks. Perhaps subsequent calculations need to wait for the results of a previous step, or the steps need to be done in order for some other reason. These require synchronous computer systems, which need to run all their processors from a common clock or time reference. One example of this is the Parallel Sysplex architecture from IBM, a method for coupling mainframes together. This approach isn't too bad if the processors are all fairly close together, but as they get farther apart latency once again becomes the limiting factor on overall performance.

In some cases, we want to interconnect processors separated by large dis-

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tances for the same reasons discussed earlier—disaster recovery. Why just copy all of your data to a remote geographic location, when you can put another computer there and be able to keep everything running even if a bomb blows up the first site? But for those annoying intervals between bomb attacks, the other computer is just sitting there, acting as an expensive insurance policy. Why not use that resource by interconnecting it with the first computer, and get twice the processing power? In many cases, this can't be done without a synchronous architecture, and the latency involved in distributing clock signals over long distances becomes a major bottleneck to performance. Superluminal waveguides would address this problem, just as they helped reduce the apparent distance between the computer and its storage devices.

In other cases, we'd like to put all the processors closer together but we can't because of other considerations, such as the physical size of the packages needed to cool and power them. Reliability of individual computer components is also a factor in how large they can grow. Consider the first electronic calculator built at the University of Pennsylvania in 1946, ENIAC (Electronic Numeric Integrator and Computer), which was limited by the reliability of its 18,000 vacuum tubes. The machine couldn't scale beyond filling a room about 10 by 13 meters, because tubes would blow out faster than people could run from one end of the machine to the other replacing them. Although the reliability of individual components has improved a lot, it's likely that we would still want the ability to swap out failed components in our modern-day supercomputers without affecting the rest of the system, and this level of modularity comes with an associated size penalty. Using integration technology available in the near future, we may be able to put a huge number of processors on a single chip; but if we have no way to repair the wafer when one transistor in the middle fails, and replacing the wafer involves stopping the entire supercomputer, then this approach quickly becomes cost-prohibitive. We're seeing examples of this today, in the form of supercomputers designed to solve so-called "Grand Challenge" problems, such as advanced genetics research, modeling global weather patterns or financial portfolio risks, studying astronomical data such as models of the Big Bang and black holes, design of aircraft and spacecraft, or controlling air traffic on a global scale.

This class of problems is also known as "Deep Computing," and typically involves high-risk/high-reward propositions. As an example, currently the world's largest supercomputer is owned and operated by the U.S. Department of Energy, to simulate the effects of nuclear explosions without actually setting them off (such testing having been banned by international treaty). To accomplish this requires a machine capable of a staggering 12 teraflops, a level which computer scientists once thought impossible to reach. Computers with this level of performance have been developed gradually over the years, as part of the Accelerated Strategic Computing Initiative (ASCI) roadmap; but the current generation, called ASCI White, has more than tripled the previous world record for computing power. This single supercomputer consists of hundreds of refrigerator-sized equipment cabinets housing a total of 8,192 processors, all interconnected with a mix of copper and optical fiber cables through two layers of switching fabric. Since the cabinets can't be pressed flat against each other (you need room to walk in and service them, or wheel out the one in the middle if it fails), the total footprint of this machine covers 922 square meters, the equivalent of 2 basketball courts (the computer also weighs 106 tons, as much as 17 full-size elephants; it was

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shipped to Lawrence Livermore National Labs in California on 28 tractor trailers, a particularly large example of PTAM in action). It's not feasible today to put the two farthest cabinets closer together than about 43 meters; but with the right kind of superluminal pipe, perhaps we can make them appear to be nearly on top of each other, a mere 13 meters apart. Don't forget that ASCI White also needs over 75 terabytes of storage (enough to hold all 17 million books in the Library of Congress), which may also need to be backed up remotely for disaster recovery; so, the effects of latency on the processor-to-storage connections also come into play. Future ASCI programs call for building a 100-teraflop machine by 2004 to address even more complex problems, with no end to the performance needs in sight. Although latency isn't the only factor limiting the performance of large computers, it will certainly become increasingly important on larger machines in the future.

Even this isn't the most ambitious computer system being built. There is a project currently under way, led by IBM fellow Monty Denneau, to construct a mammoth computer nicknamed "Blue Gene" which will be dedicated to unlocking the secrets of protein folding. Without going into a biology lecture, suffice it to say that solving this problem could lead to innumerable benefits, including a range of designer drugs, whole new branches of pharmacology, and gene therapy treatments which could revolutionize health care, not to mention lending fundamental insights into how the human body works. We know this is a massive computational problem, and Blue Gene is being designed for the task. When completed, it will be 500 times more powerful than ASCI White, a 12.3-petaflop machine—that's well over a quadrillion (10^{15}) operations per second, forty times faster than today's top 40 supercomputers *combined*. It's a design of Titanic proportions: 32 microprocessors on a chip, 64 chips on a circuit board, 8 boards in a 6-foot-high tower, and 64 interconnected towers (that's over 1 million processors, for those of you keeping track). Because of improvements in packaging technology, Blue Gene will occupy somewhat less space than required by simply extrapolating the size of its predecessors: only about 11 x 24 meters (about the size of a tennis court), with a worst-case diagonal distance of about 26 meters. With such incredibly fast processors, the effect of even this much latency is magnified; Blue Gene will be wasting about 1.6 billion operations in the time required for a diagonal interconnect using conventional optical fiber. And don't forget the storage latency: a machine of this scale is expected to have around 10 terabytes of storage requirements, easily enough to fill up another tennis court and give a processor-to-storage latency double that of the processor-to-processor latency. Because of the highly complex nature of the protein folding problem, a typical simulation on Blue Gene could take years to complete, and yield just one piece of the answer to a protein folding problem. Imagine the benefits if we could reduce this wait by even a year or so, by increasing the performance of Blue Gene and recovering all or most of those lost 1.6 billion operations.

The Future Looks Bright

All of the preceding examples illustrate how we could take advantage of superluminal propagation to increase the capacity and performance of existing computer technology. Even more interesting are the consequences of applying it to nonconventional types of computing. Imagine using very short optical interconnections, say between chips on a computer board or within a single chip (in fact, this has already been proposed by a number of researchers). If these paths were also made superluminal, then the already small latencies involved become even smaller. At some

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point, the apparent distance between transistors becomes shorter than the smallest optical pulses we can generate (a few femtoseconds, or about 10^{-15} seconds). As pulses become shorter, each pulse contains fewer photons; in this limit, the group velocity of the pulse approaches the phase velocity of the individual photons which make up the pulse. In fact, the type of superluminal behavior observed by Wang *et al.*, has also been theoretically predicted to apply to single photons.

At some point, quantum effects begin to come into play, and superluminal photons may be a mechanism for the transmission of information states in a quantum computer. This promises a revolution in computing power comparable to the invention of the transistor in the 1950s, and the subsequent radical change from ENIAC's vacuum tubes to solid state digital devices. If we continue to extrapolate Moore's Law[3] behavior, in about 20 years transistors will shrink to the size of atoms; but quantum computers would allow us to surpass this limit, using a completely different paradigm. In a conventional computer, bits of information are either on or off, ones or zeros; quantum bits, or "qubits", can exist in several states at once. This property allows quantum computers to perform many operations in the time a conventional computer takes to do just one step. Quantum computers are fairly recent, having first been proposed by scientist Peter Shor at AT&T in 1994; this year, a research team led by Isaac Chuang at IBM built and demonstrated a 5-qubit computer. This is about the equivalent of a pocket calculator. A quantum computer would need at least 100 qubits to equal performance of a conventional mainframe, and probably several thousand qubits to be really useful. Getting there involves a whole host of technical challenges, essentially rebuilding computers from the ground up, atom by atom. Even simulating the performance of a mere 40-qubit quantum computer would consume all the processing power of ASCI White for quite some time. But when combined with superluminal interconnects, the potential of this technology is truly awe-inspiring; Caltech physicist John Preskill has described it as "computational power woven into the fabric of nature" (ref. 5).

As we've seen, massively parallel processing seems to be a good way to build very powerful computational systems, provided that you can overcome the limitation of latency on the interconnections between processing nodes. This model naturally invites comparisons to the "ultimate" parallel computer, our own neural networks. We haven't yet mastered the evolutionary trick of placing millions of computing nodes in a skull-sized package with billions of very short interconnects between them (nature seems to have made the tradeoff of a package reliable enough to last about 100 years, even though it's very difficult to either regrow or repair damaged neurons). In fact, efforts are now under way to use magnetic resonance imaging techniques to measure the brain's processing power in operations per second (ref. 6). One consequence of this work, besides giving a sound numerical basis to psychology, may be a quantitative comparison between natural and artificial intelligence (it's expected that the brain should exceed at least several hundred billion operations per second, showing up even modern supercomputers for the primitive devices they are). But at what level of processing power does such a computational engine become self-aware? The famous chess

[3] Named for Intel founder Gordon Moore, this popular "law" states that the dimensions of transistor and lithography are decreasing exponentially; as a consequence, computers tend to roughly double their speed every 18 months.

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computer, Deep Blue, that defeated grand master Gary Kasparov in May of 1997, used basically the same architecture as the ASCI White machine, but was fifty times slower, and will be over a thousand times slower than Blue Gene. How much further must we reduce the processing latency before such machines start to "think" for themselves? With faster-than-light interconnections, that time may literally be here sooner than we think! □

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Part of what it means to be human lies in our relationships with those who aren't. . . .

Lost Dogs

Christopher McKitterick

Illustration by Broeck Steadman

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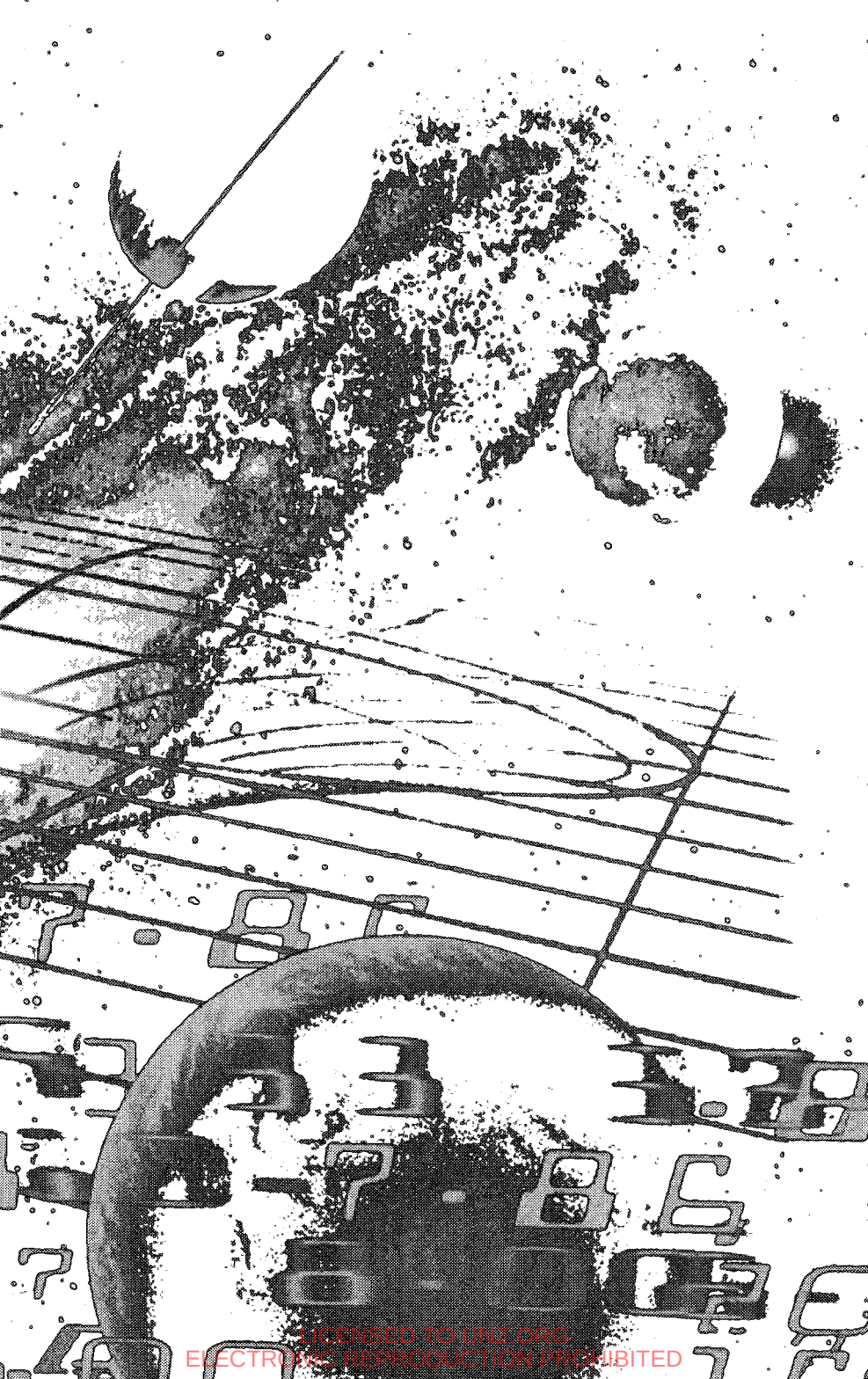

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Almost 80,000 years after the Humans had sent it to the most distant parts of the galaxy, the little probe finally found what it had been looking for. Possessing about the intelligence of an eight-year-old Human, the AI probe understood that its mission was the most important thing anyone had ever done . . . as every other such probe had also been programmed to believe. But it was smart enough to recognize when it had discovered something beyond its comprehension. It immediately knew it needed to talk to a Human, and that is better than can be said for most sentient beings.

But the probe—no larger than a basketball and pitted and stained from exposure to raw space—got so excited that it couldn't remember how to find one of its makers. After all, it had been nearly 80,000 years since the Humans had told it what to do, and that is an awfully long time for anyone to remember anything, especially a simpleminded probe who had learned so much in its years that it had to store most of its memory in a subspace mindnet. It was also the last of its kind, having evaded the roundup tens of thousands of years ago due to the very nature of its mission.

The little probe paused a few moments, its ultracarb shell aglow with the pulsating light of the galactic core, now yellow, now white, surrounded by like-colored nebulosity. Stars orbited so fast around the core that they looked like insects swarming around a light globe. The probe listened very closely with its antenna array and sensed a sort of hum like a hundred billion bees, like an orchestra of oboes. It had lived here for almost 70,000 years. This natural music always calmed the little AI, familiar and comforting. After listening for a few seconds, it remembered what to do: *Retrace my path. Eventually I'll find a Human to tell. They'll know what to do.*

It activated its subspace drive, dunking down into what looked to the real Universe like a ripple of light: a metallic pebble dropped into the galactic pond, one splash as bright as starlight, then gone. As it rolled ultraslow through the fifth dimension toward the last place it had spoken with Humans, the probe grew ever more excited. *They'll be so proud of me! I'll never have to be alone in space ever again. From now on I'll be too important to send off into the dark. They need me now. It'll be so good to be around a Human again.*

The splash reversed itself. Out of nothingness—950 light-years away from where it had at long last solved the puzzle of its lifelong mission—the probe rolled back into realspace.

Here I am, it cried. *I don't know what to do next but I know I have to talk to somebody!*

On the day the Universe changed, it so happened that John6564—not his Architallean name, but then John6564 was a Humanophile and had taken a Human name—was asleep at the helm of his Safety Cruiser. No matter; ancient Human-built artificial intelligences performed all necessary astrogation. John6564 was Prime Officer of the First (and only remaining) Defense Wing of the Architallean fleet. Once, long ago, the fleet's Wings had numbered in the hundreds, first among all the Galactic Allies. But that glorious time was three hundred generations past, and the Great Wars and their galaxy-spanning Alliances were no more than memories handed down from parent to child, parent to child, as they had always been and would always be. John6564 was the keeper of his family's memories from that Great Age, back when it meant something to be an Architallean, when merely mentioning his people's name among lesser species caused a quiet to fall over a room. But, in this twilight age, the most John6564 could hope to be was a policeman among the stars. The noble call in his heart had lifted him to space and this life, where once it would have lifted him much higher, to glory

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among the Alliances.

So when he felt the touch of a Human mind, sleep was vanquished and he leaped out of his control couch.

"What is that?" he demanded of his crew, all twelve of whom—twelve being the Great Number, as that had been the number of Great Allies and was now the default number for all the fleet's enumeration needs—now also awoke, whether it was their shift or not.

The faces of those he could see in the wide, curving helmroom stared back, eyestalks tall and beaks gaping. None could speak. John6564 understood why.

Here I am, cried the Human mind. The need in its tone instantly evoked a call to duty.

Every Architallean had felt the recorded touch of a Human mind, ancient transmissions preserved in subspace for millennia, exhumed from storage and played only once per Architallean lifetime—210 Earth years. Every Architallean old enough to count could translate local years to Earth years, the sacred time unit: Earth was the planet that had nurtured Humanity for two million years, until they departed their homeworld to conquer space. The Humans had left Earth a sanctuary, holy to all the peoples of the galaxy. It had not been re-inhabited until just 60,000 Earth-years ago, at the end of the Great Age.

I don't know what to do next, the Human mind said, *but I know I have to talk to somebody!*

At once the entire crew poured into the helmroom, their long fingers reaching for the telepathcomm equipment, the ancient Human technology which permitted sentient minds to communicate with one another across vast distances and language barriers. During the Great Age, Humans had built at least twelve Moon-sized telepathcomm transmission stations and scattered them across the galaxy. Each could amplify and retransmit mental communications tens of thousands of light-years, as fast as thought itself. Only two known stations remained intact after the Great Wars, now lovingly preserved but not, of course, in use. Who would dare induce wear upon the greatest of Human technology only to speak to someone of a lesser species? And what would one, what could one, say? Regardless, only a handful of people even knew the security codes. So the stations remained well-oiled, waxed, filtered clean, oxidizer- and corrosive-free, and maintained at a constant temperature that would have pleased the Humans who once lived there.

Yet now twelve Architalleans slapped and hit and scratched and squawked at one another, all fighting to be the first to speak to a live Human in more than 60,000 years, careless and uncaring that they might damage a piece of equipment any and all of them would have died to preserve only a moment before.

"Stop that!" John6564 said, and the others immediately ceased their hostilities, for he was their leader. "We must decide what to say before we dare respond."

"Oh, yes, sir!" his second said.

"Of course," said another.

"We were foolish," said a third.

"Not foolish," John6564 said. "It's natural. I understand your excitement. We, alone among the Architalleans, and we Architalleans alone among all the former Allies, are the first to hear from a free Human after their long imprisonment. We stand at the threshold of a new Great Age. No one expected this: How could they escape their prison? But we should have known the day would come, because they are *Human*, after all! We have to formulate just the right response, because our words will be remembered for all time, passed down from parent to child. We are the people whom the Humans contacted first. If we respond correctly, we Architalleans shall be their only Allies in this new Great Age."

"Glory to Archital!" they all shouted in unison. For the first time in 60,000 years, the phrase felt as if it held meaning.

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"This is a wondrous time," John6564 said. His beak grew damp with emotion. "Remember every moment of this day so your children may remember, as well." They set to work.

They argued about what they would say and how they would word it, how best to address the Human, and how best to sequence their requests. Once they had formulated an honorable introduction, they began to record their message on equipment which hadn't been turned on in 59,900 years.

But, before they could transmit, the Human vanished from their part of space.

Darkness fell over their hearts. Oh, the mental vacuum. John6564 slumped in upon himself, flightless wings wrapping around his slight form, long wingtip fingers locking together behind his back as he keened uncontrollably. He didn't care that his crew saw him in this infantile state, but of course none of them could see beyond their own personal sorrow.

They had failed. They had failed themselves, their lead officer, their fleet, their whole race; but, most important, they had failed a Human.

Everyone everywhere among the former Twelve Great Allies had learned that, in the end, none truly mattered but the last. For without Humans, there is no worthwhile duty. Without duty, there is no glory. Without glory, life is meaningless. How did we ever forget? wondered John6564.

"Humans taught us duty," was inscribed on a plaque in every helmroom of every Architallean ship of the fleet. "Without Humans," John23—one of John6564's ancient relatives—had argued in a bid to avoid this very Dark Age that had followed the Treachery, "the peoples now keeping watch over the galaxy would still be mindless brutes scratching nutrition from the planets that gave them life. They taught us everything we know. They made us everything we are. Without Humans, we are simply wild animals clawing at one another's throats."

Archital had been last to join the Treachery. There was some honor in that.

Recalling his heritage, John6564 dragged himself from the black hole of his despair. His lineage had a duty, and it now sat squarely upon his shoulders.

"Track the Human." So it was that his subspace operator fired up the ancient Human tracking equipment for the first time in 59,900 years.

"Gather the fleet," he said. So it was all 144 vessels (144 is, after all, a sacred multiple of 12) of the Architallean fleet began to power up together for the first time in 59,800 years. Of course, only 12 were currently on duty.

When John6564's subspace operator identified where in the galaxy the Human ship had reappeared—in Camdian space, ancient enemies of Archital, traitors against Humanity!—they shot immediately for that solar system. The other vessels trailed behind in rag-tag fashion as they were manned and their sealed systems were made operational.

Architalleans and Camdians hadn't spoken for 56,000 Earth-years; but then neither had any of the other former Allies spoken to one another. Why would they? What would they have to say?

But now, as this new Great Age dawned, they would speak. Oh, yes, they would speak, and there would be war, glorious war, as would please the Humans!

Barry walked along the railroad tracks outside Ortonville, Minnesota. No actual tracks lined the raised path anymore, as they had been torn out in the 1980s, which made for easy walking. He kicked an old beer can toward the dump, and used a word his dad had used that morning. Today had started out bad, especially bad considering tomorrow was supposed to be his stupid twelfth birthday and you're supposed to look forward to birthdays, especially during summer vacation. Lately, he didn't seem to look forward to any days. His parents were fighting a lot, and he always tried to make

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them stop fighting. But that only made them madder—and mad at him, too.

Something scurried through the trash near the path, big and brown and furry. Barry picked up a stone, his pulse racing. His dad had taken him here last summer when the dump had hired him to shoot rats. They were filthy things that carried disease. Hitting a stupid rat right now would make Barry feel a little better, he thought. Barry crept closer to the nearest heap, a hill of discarded junk and rotting food taller than he was, and dashed into the driveway between heaps, arm cocked. The animal leaped away, but not before Barry let loose the rock. It thudded against the creature—just as Barry noticed it wasn't a rat at all. It was a dog. Barry gasped, guilt crashing down on him at the very moment of sadistic elation.

The dog yelped and ran behind a gutted car.

"Sorry, boy!" he said. He felt like crying. How come everything he did turned out the opposite of what he meant? How could he make this one work out OK?

Barry pulled off his backpack and reached inside. He pulled out half of a cheese sandwich he'd packed after this morning, after deciding he was going to run away. "Here boy! Yum, a sandwich."

Barry crouched low so as not to scare the dog any more, holding the sandwich out. The dog peered through the doorless car. Barry could see it was medium-haired, kind of a shepherd-looking thing, medium-sized, brown like the sand on a dirty shoreline. "Here you go, Sandy," he said. "I didn't mean to hurt you."

The dog whimpered, circled behind the car, and poked its nose into the car again. Its nostrils wiggled vigorously and its brown eyes stared at the sandwich. Barry crawled on the hard-packed dirt until he reached his side of the rusty car and set the sandwich on the floor where the seats had once been. At first, the dog backed away into the weeds on the other side of the car, but then rushed forward and snatched the food in a flash of fur and teeth. After a momentary scare, Barry laughed.

"Good boy!" he said, and sat back. The dog didn't even chew as it gulped the food. A few seconds later, it appeared at the front of the car, tail wagging low to the ground, head down. Barry looked into his bag. Two and a half sandwiches left. He took out the other half of the cheese sandwich and held it out.

"Here you go, Sandy," he said. The dog's tail came right up and his big ears went back, dumb grin lifting his lips. But it took the dog about two minutes of getting closer, tail drooping, whining a bit, circling away, then coming back before he got close enough to take the food. Barry told the dog how sorry he was, and as soon as it got close enough to pat, Barry scratched it and began pulling the thistles and brambles from its coat. He told Sandy about why he was running away, figuring the dog understood—it was alone in the wild, too.

Well, that's all it took. From then on, Sandy walked with Barry, never farther away than twenty feet. Barry figured it was good that he'd made friends with a dog, since being eleven and alone in strange parts of the country could be dangerous, especially when he didn't plan on coming back to Ortonville ever again.

Beyond town, the tracks become more and more overgrown. Barry didn't mind the weeds, and Sandy seemed to like them, rushing through the dusty stalks and snapping at grasshoppers. Sandy always circled back before long, smiling and looking to be patted every so often. Barry smiled a lot, too. He'd never had a dog of his own, and it seemed he had one now.

Running away was turning out to be a good idea, after all.

John6564's cruiser and dozens of other Architallean ships appeared in the Yaminah star system only moments before the Camdian and Danali fleets appeared. Even so, they had missed the Human,

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again. The Camdians opened fire on the Architalleans immediately, and the Danali responded by firing upon both the Camdians and John6564's fleet. Everyone seemed to argue that it was the *other* Allies who betrayed the Humans and deserved punishment. Liars!

"Where is the Human?" John6564 demanded of his crew. His ship performed a high-g maneuver, narrowly getting out of the way of a Camdian antimatter missile. John6564's vision cleared just in time to see a heads-up display of a full net—three groups of twelve—of missiles racing in upon his vessel like a shrinking sphere.

"We need to leave now!" his pilot squawked.

"Not until we have the Human's coordinates," John6564 shouted. The heads-up showed that, of the 319 vessels from the three civilizations involved in this battle, half were taking serious damage. The Architallean fleet was faring the best, of course—partly because they had the largest number of ships, with more joining from the home system every moment. Unfortunately, many of them were becoming too damaged to follow John6564 when he moved on to the next destination. But this was turning out to be a real war! That much was for the good.

"Got it!" shouted the astrogator, and the pilot sent the coordinates out to every other Architallean vessel at once, then went subspace only seconds before the missiles were to detonate.

During the moments his ship spent in the utter dark of subspace, John6564 panted—part in relief, part in desperation, but mostly in excitement. He was living the dream of all the Lesser Species! A new Great War was upon them, and he was carrying it with him across the galaxy, to the Human himself. The Human will be so proud! he thought. His neck feathers fluttered.

Sometime after his feet grew sore and his sandwiches and chips ran out, Barry decided maybe he'd go home, just for one more day—for his birthday, anyway. He could run away again after seeing if his parents would be nicer on his special day. Anyhow, Mom and Dad loved dogs—they had bunches of them, though none as nice as Sandy—so maybe they'd be happy when they saw he had a dog now, like them, and a nice one at that. One a guy could sit down with and pat. Barry liked that about Sandy. He'd never patted a full-grown dog before, though he saw them in the backyard every day. Sandy was good to hug when you got tired and had to sit down, warm and kind of dusty-smelling.

He rounded a corner as the track cut through a small hill, tan with weeds, the occasional purple or white wildflower bright amid the uniform browns. Barry's chest grew tight as he walked closer to his house, remembering how his mom and dad had fought this morning, like they had fought yesterday and the day before and the day before that. He remembered when he was a little boy and they had laughed a lot. Those were nice memories. He couldn't understand why they wouldn't want to live like that again. Surely they wouldn't fight when they saw that their son was walking in their footsteps, getting a dog of his own!

Their backyard was hemmed in by a tall hurricane fence to keep the dogs inside when one of them was taken out of its kennel for training. Right now, Dad wore the thick armpad, and a young Rottweiler was doing its best to pull it off the man's arm. So Dad didn't notice the boy until after Barry stood near the gate.

"Dad, look who I found!" Barry said. "His name's Sandy and he's the nicest dog you'll ever meet."

Before Dad had a chance to react, the Rottweiler launched straight across the yard at Sandy. Sandy leaned close to Barry, ears and tail down, chest vibrating with a growl. That only made the Rottweiler angrier, and it jumped the last three feet at the gate. Barry's dad often tried to save money, and it seemed the

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gate was one of the things he'd saved money on, because the folding lock-lever bent and the gate crashed open against Barry and Sandy. The last thing Barry heard before the barking and snarling was Dad screaming at him.

"You idiot! What do you think you're doing bringing that mongrel here?"

The two dogs became a swirl of black and brown snarls, fur tufting into the air along with yelps and the occasional blood droplet. Barry began to cry, not knowing what to do, wanting to stop the Rottweiler but terrified. He pushed at it several times, only getting clawed and shoved back for his efforts. Mom ran out of the house, hands waving over her head as she shouted something Barry couldn't hear. Dad waded into the dog-fight, hitting with his padded arm and kicking at the brown part of the fight, until Sandy yelped especially loud and ran away. The Rottweiler tried to follow, but Dad grabbed it with his elbow around the neck and affixed a leash to its studded collar. Barry turned to see where Sandy was going.

"Stupid kid," Dad shouted, holding his dog down with the padded arm. "Do you have any idea how much these dogs are worth?"

"Don't call your son stupid," Mom said. She stopped near them, arms crossed and cheeks red. She smelled like dish soap. Then she turned to Barry. "Where did you find that mutt?" Barry tried to answer, but they ignored him. He couldn't stop crying. They never listened to him when he cried, but he couldn't help it sometimes.

"He's not my son," Dad said, "and I'll call him anything I like."

"If he's stupid, he must be your son," said Mom.

Instead of yelling back at Mom, Dad turned a red, scowling face to Barry. "You're always making life miserable! Get the hell out of here and don't show your face any time soon, you little shit!".

Barry had had enough. He'd heard all this before and knew the kinds of things they'd say and do next, only he bet it'd be a lot worse now. I've screwed up big this time, he thought. Got to find Sandy.

So he took off again, sobbing, vision blurred. He fell a whole bunch of times as he ran along the railroad tracks. The sun went down behind the cornfields, and the trees along the tracks grew darker, and soon Barry couldn't run anymore. He lay down by a tree with thick branches that he liked to climb and let himself cry for real. The night was starting to feel cold and damp, and his face was getting muddy from dust and tears.

"I don't ever want to see them again!" he said. He wished Sandy were with him now; he would be good to hug. He wished he could stop everyone from fighting. He hoped his dog was OK.

The little probe entered realspace in yet another star system where he remembered Humans used to live. At least, this had once housed an Alliance base, and Humans always lived on those bases.

Here I am, it cried. *I don't know what to do next. Is anyone here?*

It waited an hour, as usual, rebroadcasting its message over and over. The base didn't power up. Nobody answered. It was about to leave again when one of the aboriginals answered.

Great lord and master, was the reply, *we have waited 60,000 years for this moment. First we must tell you that we were against your imprisonment—*

What're you talking about, Lesser Ally? the robot asked, curious that it was being addressed as if it were a Human, yet hesitant to correct this error if it could lead to information about where to find a real Human. *Where have the people gone?* it added. By "people," it naturally meant Humans. All the lesser species understood that.

My lord, were you not imprisoned on Earth, Sol System? the alien asked. *That is where all the other Humans are, where they have lived in ignorance, toiling in the dirt since the end of the Great Age.*

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Your lineage must have escaped the Unforgivable Treachery. Glory upon the Forebears! Our people, the R'kak'gra, defended you during the Trials, showing that Humans brought us enlightenment and glory beyond all history's glory. We prepared to fight and die in your service, for our entire race to perish from the Universe. And we did resist the Treachery. We, alone among the Allies, stood by your side as the others turned against you, as they spoke lies about how your people brought about all the troubles and the Great Wars that followed. No troubles could have been great enough to turn the R'kak'gra against Humanity! But traitors in our midst kept us from acting in time.

This was all news to the little probe, but it only became more confused. It couldn't bear much more confusion.

So the other Allies turned against your people, working together against Humans instead of in the service of Humans, as it had always been before and will be again. During the Dark that came after the Great Age, the Alliances destroyed many of your technology gifts and drove the surviving Humans to your . . . rest planet, Earth. Here is the full history; and it opened a path to a subspace storage. The robot linked its memory to this one, downloaded the information, and prepared to leave.

Tell us, oh lord, how your forebears evaded—

But the little robot had heard enough. *Thank you*, it said, and left.

During the journey to Earth, Sol System, the little probe studied galactic history. It watched (rather, it experienced via deep-memory sump) cities flash to fire and dust; fleets of alien spaceships—fighting in Humanity's name, each allied to a different Human sect—tear each other to shrapnel and freeze-dried flesh; it saw worlds shattered and stars blown up and whole intelligent species extinguished in what were now called the Great Wars.

The little robot had never studied this type of information before, and doing so now, all at once, when it was so very lonely, nearly destroyed its fragile psyche.

For how can someone survive the discovery that its lord and master is the most horrible creature that ever existed?

The robot emerged into realspace over the planet Earth, the first vessel to visit in 20,000 years. It heard the lesser species' alarms go off. The probe knew the aliens would arrive soon, most probably to destroy it. It knew the Humans scrabbling on the surface of the blue world below . . . for the first time, it *knew* them. It was quiet for many long, quiet seconds. It tried to imagine the peace it felt when it listened to the music of the galactic core. What would the thing that lived there have ordered it to do?

There was only one course of action. It may have been a primitive AI, but it wasn't stupid. The probe picked a remote outpost of Humanity at random and dove down to meet its wicked master. It very nearly experienced an emotion it had never executed before, but it was not ready for such things just yet.

John6564's Safety Cruiser and eleven dedicated escort vessels—as the rest of the fleet was in action en route—arrived at R'kak only minutes after the Human had left. When he realized that the Human had once again moved on ahead of them, he ordered his subspace operator to locate its vessel in what was becoming a routine. Eventually, they would find the Human. Perseverance in duty is the greatest good.

Wisps of smoke stung his eyes as his crew searched for the Human.

"Architallean fleet," the comm system croaked in the ugly accent of a R'kak'gra, "you have violated our space. We invoke the Great War Articles. You are now our enemy and will be destroyed."

John6565 sighed, his breath harsh in his burning throat. The pilot was squawking nonsense—and loudly, too! John6564's excitement had long since worn off. He was beginning to worry

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more that he might not survive to watch Humanity and Archital renew their Alliance.

"Operator, have you found the Human yet?"

"Soon, sir," the officer said, eyestalks sunk deep into the viewing tank. "It is in the Second Galactic Arm." Her left wing had broken in the battle near Mannos, during their fourth stop. Blood soaked her once-spotless uniform. The enemy had suffered far greater casualties.

"The R'kak'gra fleet approaches," said the hologram of the Prime Officer of one of his escort vessels. "They number 29, each a match for one of our own. Shall we stay and fight or go with you?"

John6564 squeezed the grips of his couch, drew a long breath, and decided he had left enough wars trailing behind him. Six of the Twelve Alliances were now at war with Archital, fighting the parts of the Wing John6564 had left behind to keep those aliens from following him. Unfortunately, each race had also heard the Human and were tracking it, as well, so each of its stops created larger and larger battles in its wake, the victors jumping to catch up as soon as they could. Archital could not be victorious in every battle.

"Come with us." He turned his eyes to the subspace operator. "Do you have the location?"

"Near enough, sir. In the Sol System."

"Sol System." John 6564 marveled in silence. Billions of Humans lived there. He made the only decision he could, damn the Highest Law: "We go."

As stray photons rejected subspace travel, twelve ship-sized splashes appeared in space like a shotgun fired into a pond. The R'kak'gra would have to wait another half hour for the war to catch up to their solar system. But that would be easy enough for them; they'd already waited 60,000 years. There was time enough for everything.

Barry lay quiet beneath the tree, looking up. Night had fallen in Minnesota; stars shone through the leaves and branches overhead as bright as car headlights on the highway, and the Moon was as bright as a floodlight. He could see the Man in the Moon up there, could nearly touch his white and gray face.

Barry heard something scuffling through the weeds near where he lay. He sat up and listened. A quiet, familiar whine.

"Sandy?" When he didn't get a response, Barry swallowed hard. He made the ancient lip-smacking sound people have used to call dogs for hundreds of thousands of years. It worked.

Sandy stepped close enough so that Barry could see him in the semi-darkness. "Sandy!" he said. Tears warmed and then cooled his cheeks as he saw the dog, *his* dog, no matter what his parents said! He was going to keep Sandy even if that meant riding a boxcar somewhere far, far away from Ortonville.

And good riddance! he thought as he got to his knees and put out his hands for the dog. Sandy trotted straight to him, head down but tail wagging.

First, Barry squeezed him close, absorbing his doggy warmth, then felt along his hide for wounds. A few sores around the shoulders, but nothing too bad. The Rottweilers looked worse after the times two or more of them accidentally ended up in the same run or training area. A warm breeze brushed Barry, quickly fading.

Sandy went rigid and began to growl, the same vibration deep inside its chest it had made before the Rottweiler attacked. "What is it, Sandy?"

"Human?" a stranger asked. Barry jerked, then jumped to his feet. He couldn't tell who was speaking or where they were. It sounded kind of like how your own voice sounds in your head.

"Who's there?" Barry said. He couldn't see anyone in the moonlit grass.

"I am—" then it said something that made no sense. Barry couldn't decide if the voice was a man's or woman's, and it had a weird accent. Mostly female, he de-

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cided. And very sad, though Barry couldn't decide how he knew that. So sad the voice made Barry want to cry again, and he would have done so if he hadn't been so scared and tired.

"I completed my mission to discover—" and then the voice went on about stuff Barry couldn't understand, things called quasars and black holes and pineal glands and subspace nervous systems. Barry looked all around in the dark and could only see Sandy, growling, pressed against his legs, looking up. Barry followed Sandy's gaze and saw something that looked a little like a ball in the branches overhead. Was the person up in the tree . . . ?

"I don't understand," Barry said.

"You sent me on a really long mission to learn this:" the unseen person said.

Then it was as if the sky fell. Barry dropped straight to his knees in the dirt and grass.

In a few seconds, Barry learned everything every person on Earth had ever known about physics and chemistry and biology and engineering and all the other sciences, and then everything every Human in the galaxy had ever known, and then he learned everything the little robot had learned on its journeys around neutron stars and through black holes—the back way, via subspace.

He felt the raging wind of a supernova. He watched stars born and die. He felt the galaxy pinwheel beneath him. He met the thing living at the core of the galaxy and shook its hand, which tasted like the spectrum of every star the little robot had ever studied, with Fraunhofer lines for its fingerprints and nerve-tingles for a voice.

And Barry was scared. This was so much to learn, so much experience, that he had to fight as hard as he could to remember who he was: A boy growing up in a small Minnesota town, on Earth, during the Galactic Dark Ages . . . no, the last was wrong. He hadn't known about that before this machine . . . yes, this ancient space probe, had opened a subspace telepathcomm channel from the machine's subspace memory to Barry's mind. I am Barry. I am a boy. I am Human.

But the probe didn't stop during Barry's crisis of personality, didn't even notice. This is how it learned, and this is how it was taught to brief Humans upon return. It didn't know any better. Barry's body lay curled tight, knees to chest, fists to ears, Sandy licking his hair into cowlicks.

After science, Barry learned history, but not the thin progress of Humanity in this little prison; no, Barry learned the million-year history of galactic civilization that the probe had gotten from one of the aliens. He watched little pink things crawl out of the mud, become Human, and build crystal towers to the stars; he watched birds abandon their nests for floating cities that Humans helped them build; he watched a hundred weird and astounding species ascend to sentience with a hand-up from Humanity, build civilizations out of raw desire, and then reach for the stars. He watched them meet one another and then witnessed the inevitable squabbles that followed; those squabbles led to early wars, so Barry learned of the Galactic Accord and the Million-Year Peace.

All this was weird and wonderful to Barry, like the science-fiction stories he read at the library. Now that he understood science, he couldn't help but smile a little at the silly notions the writers had about aliens and space travel. It was all so much simpler than that. But his smile transformed to a frown when he remembered a book by Bradbury called *Dandelion Wine*, because Barry knew that during this education he was losing all that defined who he was. So he fought to remember what it meant to be Barry. And he thought of Sandy. When he thought of his dog, he felt the concerned licks and relaxed some. His dog was standing guard over the boy he still was on the outside.

Barry learned about the divisions with-

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in Humanity that rose out of too much peace. As great as we ever were, he thought, we were still just as much wild animals as those we helped to sentience. He understood the power and glory that the ancient and complacent beings had gained from this vibrant, magnificent new race, nearly as magical in its technology and willpower as the entire Galactic Accord combined when it used its mental amplifiers; he watched Alliances form as each species raced to partner with this mighty force and the galaxy-spanning wars that followed. Barry felt a pain greater than any he imagined he could feel, a mortal wound to his soul, when he learned that those wars led not to a bloodied defeat but to evil beyond the understanding of any one boy: "Sterilization" of entire worlds, many old enough to have spawned a hundred Human races. He watched atrocities that would turn a torturer's stomach, things his own ancestors had done or overseen. Some recorded firsthand and replayed without feeling by this little, devoted probe.

Then quiet, dark. He closed his eyes. It took Barry a few minutes to gain equilibrium in his new state. He considered for a moment whether the probe had performed this education with sadistic glee, but of course it was only a probe of old design, barely more self-aware than Sandy.

Sandy was licking Barry's face. Barry recognized the warm, wet tongue, insistent in its concern. He also could imagine the genetic structure that led to certain kinds of growth that had developed into taste buds in Sandy's mouth. He saw the genetic imperative of DNA and how it had shaped chemicals into things like dogs or boys. He was afraid to open his eyes, because his eyes were already far too open for him to fully interpret what he could see with them closed, and he couldn't stop from weeping as it was.

But he had to, because he was aware of the mission this little probe had unwittingly brought before him. When he opened his eyes, Barry saw not the train tracks or a tree or even his dog; he saw the Universe spread out before him in whatever way he wished. Only he had trouble controlling his wishes for a moment. After concentrating, he was able to sit up and pat Sandy, and then see Sandy: simply a dog in the weeds, tail wagging, filth in its fur. He stood, shakily at first, then made fists and squinted until the world's spin didn't make him so woozy.

With a thought, Barry activated the secret telepathcomm transmission station within the Moon. In turn, it activated the three other stations known to the Allies, and those in turn activated two more hidden stations. Only a Human mind could control them as mental amplifiers rather than simple communication stations. For the first time ever, all the stations were tuned to only one Human mind—Barry's. Barry knew that during the previous Great Age, the dissonance of Human "voices" had been amplified and broadcast throughout the galaxy. Every noble, loving, greedy, vicious Human thought, feeling, and order was impressed upon every other alien mind.

"We made the wars," he told the little robot. It acknowledged him in its native language, hesitant and full of uncontrollable emotion—it hadn't been designed to feel so much, and now that its duty was complete, it was confused and scared.

"We made them all love us," he told Sandy, rubbing the dog behind the ears. Sandy loved him even without the subtle, mental orders to do so. Barry had to force an effort to feel the fur of Sandy's neck now that his mind was scattered across the whole galaxy, from here to the core.

"You two calm down now. I'll take care of everything." Sandy settled in the dust at Barry's feet and licked his wounds. The probe didn't relax so easily.

With his new understanding, Barry saw that the only reason the allied aliens had defeated the Humans was that Humanity had been too at war with itself to send a unified order to all the other species of the galaxy. Now Humanity

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possessed only one voice. And the thing that the little probe had taught Barry made all the difference in the world.

"Thank you, KnowlegeSeeker," Barry told the probe. He left off its numerical designation because he knew it was the only remaining such robot. "You've done very well finishing your studies and telling me what you learned. I'll make everything all better now, and you won't have to worry about your masters doing evil any more."

Barry felt tears on his cheeks again, but his emotions were too complex at the moment to know if he was feeling extreme joy or sadness. "You're a good little probe. Now rest." So the robot settled to the ground and put all of its memories—except those of its earliest days with its programmers—into subspace storage. It had much to sort out now. Sandy edged close to the machine and sniffed, cautiously.

Barry raised his eyes to the stars. With his new eyes, way out *there*, he saw thousands of spaceships shooting at one another, hundreds of thousands of aliens trying to kill each other to prove themselves worthy Allies of Humanity.

It took him a moment to pull away from his body again, to *feel* with his extended subspace nervous system and make it react as if he were, say, picking up his book bag.

Stop, he commanded. The amplifiers and what he had learned from the probe's 80,000-year study made it easy enough.

Thousands of miles above the surface of the Earth, six smoldering and laser-blazing fleets of ships appeared from subspace, converging upon the point where the probe had appeared. These six fleets clashed with one another, their crews' blood hot with ancient enmity and lust for glory. Atop that, everyone knew that they were within light-seconds of billions of Humans! John6564 was not immune to this magic. Though his ship was on fire, he fought as hard as any Architallean had ever fought, shouting orders to launch nukes and fire x-ray lasers and . . . .

John6564 felt a Human mind touch his again. This time it spoke only one word, but so much more than a word, and so much more clear.

Stop, it said, and John6564 found it impossible to pursue the battle.

Within that one word—that irresistible command—and the feeling it filled him with, he knew he would never again feel lonely or in want of a master; but he also knew that Humanity had become something far greater and more potentially terrible than ever before.

With the realization came such pride that his feathers stung his flesh. And then a touch of fear.

Barry willed himself home through subspace easier and faster than any subspace drive, something no Human had ever been able to do before. Odd, he thought, we had the technology in place and almost all the knowledge. Bringing Sandy along was no more difficult than asking the dog to follow. Barry drew a deep breath—nervous because he was still a boy no matter how much more he had become—as he opened the back screen door with his physical hand and stepped physically into the kitchen. Mom and Dad sat at the chrome and Formica table, cans of beer in hand.

"Why, you little—" his dad said, starting to rise, fire and bruises in his eyes.

"Where have you been, you—" his mom said, rising as well, hand cocked to smack the boy across the cheek as she had so many times before, unaware or uncaring of the ring on her finger that could bruise and cut.

Stop, Barry commanded. And they were quiet and still. Rudimentary understanding filled their eyes as their mouths opened, quiet. It would take much longer for people like this, Barry thought. His dad nodded, once.

"Things will be different now," he told them.

And they were. ■

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Upgrades can be traumatic even now, but just wait. . . .

The Upgrade

Brian Plante

Ian Meyer scanned through the morning's financial news on his computer tablet over breakfast, looking for any tidbits of information that might give him an edge over the other financial advisers at the office. A possible merger here, a threatened change in the tax code there, a shift in insider trading, it all went into his lobe. He would have some ammo to convince his clients to move their money one way or another. It didn't really matter where, just that they moved it *somewhere* else, so he could collect a commission for the company. He absently scratched the bulge at the back of his head where the artificial brain lobe was housed.

Susan, Ian's wife, entered the dining area carrying Trudi, their two-year-old daughter. As usual, Susan was dressed and made up for a day at the country club with her lady friends. Ready for another hectic day of keeping up with the Joneses, Ian thought, returning his gaze to the data tablet.

"Freeman, I'll have two eggs, scrambled, toast and tea," Susan said. "And some oatmeal for Trudi."

"Right away, Mrs. Meyer," responded Freeman, Susan's domestic robot, from the adjoining kitchen. "May I suggest Immuni-Tea brand tea, the perfect blend of black and orange pekoe, fortified with six antioxidants and neo-antibiotics? That's Immuni-Tea—for you, for me."

Ian heard Susan mutter something at the robot as she placed Trudi in the high chair.

"I'm sorry, Mrs. Meyer," Freeman called from the kitchen. "Could you please repeat that last command?"

"Mrs. Meyer said the Lipton or Tetley tea would be fine," Ian said, without taking his eyes off the tablet. "Whatever we have on hand."

Susan finished buckling Trudi into the high chair, sat down across the table from Ian and crossed her arms. "You know, this robot is driving me nuts."

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Ian sighed. "We don't have to have a robot," he said. They were going to have *that* argument again.

"Of course we have to have a robot," Susan countered. "Absolutely *everyone* at our station in life has a personal robot. Just not such a cheap one."

Freeman entered the dining room, striding briskly in the mechanical fashion, carrying a tray of food. He deftly placed the two eggs, scrambled, toast and tea in front of Susan, and a warm bowl of oatmeal in front of Trudi.

"Would you like me to feed Miss Trudi?" Freeman asked.

"Of course," Susan said.

Ian sighed. God forbid that Susan should get her hands dirty feeding Trudi herself.

The robot glided smoothly to the side of the high chair, then settled into a crouch, and began serving up the cereal, expertly timing the spoonfuls into Trudi's eager little mouth.

"The robot works just fine," Ian said. "It's not much different from one of those expensive models your hoity-toity friends own."

Susan stuck her tongue out at Ian.

In the high chair, Trudi began fussing at the rising tone of her father's voice and jerked her arm, sweeping the cereal bowl over the edge of the high chair's tray. Freeman's arm abruptly shot out to catch the falling bowl, but he was a fraction of an instant too late, and the bowl crashed to the floor, shattering on the terra cotta tiles.

Ian groaned and returned his gaze to the data tablet.

"Soirée dinnerware is on sale at 20 percent off, this week at Kitchen Pantry & Parlor," Freeman said, already making his way into the kitchen to retrieve another bowl of oatmeal and a mop. "Why eat from ordinary dishes when you can have a Soirée?"

"See what I mean?" Susan said.

Ian put the tablet down on the table and pushed it away. There would be no more reading until he got into the office. This little domestic scene would play out again as it had a dozen times before, each one indelibly etched word for word in the memory banks of Ian's lobe. It was like a train wreck that you could see coming from far off but were powerless to stop.

"What?" Ian said. "Trudi broke the dish. Freeman did a perfectly fine job feeding her, up until that point. He almost caught the dish, too. What, do you really think your lady friends' fancy expensive robots would have done any better?"

"It's not the dish," Susan said. "It's the constant barrage of advertising that I have to endure. Immuni-Tea. Dishes at Kitchen Pantry & Parlor. At the club, he tells me that Love-Forty tennis balls have the most consistent bounce and why Callipygia swimwear will flatter my figure. It's so embarrassing to have to endure that in front of my friends."

"Like I said, we don't have to have a robot. Not everybody does, you know."

"Everybody like *us* does. And not one of these stupid *free* robots, either."

There was no way that Ian was going to spend good money on some expensive mechanical servant to indulge Susan's life of leisure. Ian had always argued that they couldn't afford one of the regular, paid robots, but Freeman was advertiser-supported. The Freeman Robot Company had offered the free ones to families that qualified demographically, and Susan had taken them up on the offer. A free robot was better than no robot at all, or so she had originally thought.

"If the robot is embarrassing you in front of your friends, then why don't you just leave him home?" Ian asked.

"What, and drive the car myself? People will think . . . we're *poor*."

Oh, the horror, Ian thought. How had Susan gotten so materialistic? How had he let her? She hadn't always been that way.

It had started just before Trudi was born. Susan used to have a regular job

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back then, and they were both happy and still in love. Shortly before the baby was due, both of them decided that it would be best for Trudi to quit work for a few years to stay home and raise the child. It was an old-fashioned idea, but they thought it was still the best way.

To make up for the lost income, they both agreed that Ian would get the artificial brain lobe put in.

Ian's boss at the company, Mr. Canary, had been telling him for some time that if he got one of the new lobes, he could guarantee him a raise in salary. And it had worked, for a while. Ian got the lobe put in at the company clinic. It was a routine, painless operation that left a sizeable bulge on the back of his cranium where the new lobe was installed. After that, Ian had been able to capture and keep a slightly better class of clientele, and Canary had rewarded him accordingly.

But things had changed on the home front. With some free time on her hands, Susan had fallen in with a group of other stay-at-home mommies. Since most of these friends were the wives of Ian's clients, they were considerably more affluent than the Meyers, and their attempts to drag Susan along into their social strata had been costly. Worse, it had changed Ian and Susan's fundamental relationship. Before, they had been happy and in love. Now, they argued about money all the time. Ian worked hard for a living, and Susan kept up the appearance of not needing to.

"You know," Susan said, as Freeman mopped up the spilled oatmeal, "Rita Henman says you can get a promotion at work if you upgrade your lobe."

"I already have a lobe. Rita Henman should mind her own damned business."

"But they're paying extra if you have one of the new megalobes. Rita spoke to Ellen Canary, and she says her husband was begging you at work to get an upgrade."

Yes, Mr. Canary had mentioned it at the office. Several times. And Ian had actually looked into the new megalobes. Unfortunately, the cost was prohibitive. The Meyers were already deeply in debt, and Ian feared going any deeper to pay for more brainpower, even if it was general knowledge around the company that management expected you to keep your lobe current.

He also didn't want to go under the knife again, just so his wife could have more money to throw around frivolously with her rich friends.

When the artificial brains had first come out, the company had put pressure on all the financial advisers and analysts to have themselves enhanced with a lobe. Then, just as now, the price was dear, and the company used it as a test of loyalty. Employees who spent the money and got a lobe were displaying a commitment to their job, and got promoted. There was still a place at the company for the unenhanced, but it would always have a lower ceiling.

Now, two years down the line, Ian's early-model lobe was a veritable dinosaur. Where before, the bulging cranium had been a badge of company loyalty, now artificial brain lobes were practically a requirement. Clients *expected* it, and the important clients got what they wanted or they took their money elsewhere. And when nearly every financial adviser had a lobe, the competition was on to see who had the *best* lobe. After all, if you were a customer, who would you trust your money with: some pipsqueak with more meatbrain than lobe, or some hungry up-and-comer with enough brainpower to run a small country? The model number of the lobe they used wasn't just something to list on their résumés, it was trumpeted on their business cards. Some of the financial advisers and analysts at the company were already on their third or fourth lobe.

"We agreed you'd get the lobe so we could afford to have me stay home and raise Trudi," Susan said.

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If only she would stay home, Ian speculated, maybe he wouldn't need a new lobe. But he thought better of voicing that opinion, this time.

"Getting your lobe upgraded is part of the deal," Susan continued. "If the lobe you have isn't good enough to financially support us comfortably any more, then you aren't keeping up your end of the bargain."

"But do you know how much these new megalobes cost?" Ian said. "With the way you spend money, we just can't afford one."

"The ladies at the club say you can't afford *not* to get one, if you expect to keep moving ahead at work. You do want to keep our daughter well dressed and fed, don't you?"

There was her secret weapon: throwing Trudi at him. He could easily tear her apart verbally for her jaded laziness, but Trudi was still the innocent one. Of course he wanted the best he could afford for her, and the threat that he would fail at work and not be able to provide for her was a real fear. Susan knew it was one of Ian's hot buttons, and Ian knew Susan knew. He hated being played for the fool, but Trudi shouldn't be made to suffer for their differences.

The argument was interrupted as the phone rang.

In the kitchen, Freeman answered, "Good morning. This is the Meyer residence."

After a pause, Freeman entered the dining room carrying the phone and announced, "Mrs. Rita Henman, calling for Mrs. Meyer."

Susan took the phone and said hello.

Ian thought it might be safe to escape now and go to the office while Susan was occupied with her call. But he knew it would just prolong the argument, which would be waiting for him when he returned home.

"Yes, Rita," Susan said into the mouthpiece. "Yes, I told him. Of course, he says he wants to keep up at work, but he's balking at the upgrade. I don't know what I'm going to do with him."

Ian drummed his fingers on the tabletop and glanced at his watch. How dare she talk like that about him while he was sitting right there?

"Well, don't worry," Susan continued, "I won't let anything like that happen to our little girl. I know she needs a new computer. Ian may be cheap, but he's not stupid. I just have to work on him a little more. I'll see you later on at the club."

Susan handed the phone back to Freeman, who said, "You can get twenty minutes of long-distance service from KlepTel for only twenty-six cents. Let me know if you'd like more information. Some restrictions may apply."

Susan clenched her jaw and shot Ian a look. He shrugged his shoulders, so she picked up an uneaten piece of toast from her breakfast plate and flung it at the robot, leaving a greasy spot on his gleaming metal housing.

"Would you care for some more toast, Mrs. Meyer?" Freeman said. "Or perhaps some original Gerald's Olde English Breakfast Scones, with plenty of cracks and crevices to hold the butter. Gerald's—a breakfast tradition since 2001."

"I've had quite enough of you, you piece of crap," Susan said.

Ian rubbed the bulge at the back of his head. He felt the beginnings of a headache coming on.

"Leave the robot alone," Ian said.

"What are you going to do, stick up for me or this worthless pile of metal?" Susan said.

"He can't help the advertising," Ian said. "That's what he's programmed to do. The waiting on you hand and foot is just a side benefit."

"If you spent a little money, instead of being so goddamned cheap, we could get a robot that doesn't embarrass me at every turn."

"So, what are we arguing about here?" Ian asked. "The robot or the brain lobe? Which is more important to you *this*

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morning?"

"If you got one of the newer megalobes, you could get a promotion at work, then we could afford a new robot—a regular robot without advertising. And a new computer for Trudi."

A computer for a two-year-old, Ian pondered. When he was a child, he didn't get his first computer until he was nearly ten years old, and it had been an ancient laptop model with an old-fashioned keyboard built in instead of the usual tablet-style pad with voice control. But computers were important, yes, for two-year-olds these days, and if Trudi needed it, he would get it for her. Somehow.

He looked over at his daughter sitting in the high chair, with some alarm on her little face because of the tone of her parents' voices. She was a pretty kid, with more of her mom's good looks than anything Ian might have contributed to her physical makeup. It reminded him of better days when Susan had been younger and they were still in love, every time he looked at his daughter's face.

Was it his fault that they were hurting for money? He hadn't changed; it was all Susan's doing, wasn't it? He may have been at fault for letting her get this way, for not stepping in and hauling her back to earth when her rich friends put stupid ideas in her head, but it was mostly her fault. He was still a good provider, but she just always wanted *more*.

But when it came to Trudi, who cared whose fault it was? She was young and needed a mommy at home, not some nanny robot filling her head with advertising propaganda twenty-four hours a day. She *did* need to be housed and clothed and fed in a reasonable style. And yes, she probably did need a computer tablet, and maybe a dollhouse, and then a flute or perhaps a violin, and one day a prom dress, and then her first car, and then college tuition, and then a respectable wedding. Daughters were expensive propositions.

Ian would do what needed to be done to make Trudi happy. Perhaps he *wasn't* keeping up his part of the bargain if he didn't get a new megalobe.

Mr. Canary was a lobe chauvinist. He commanded a corner office with a view of Broad and Wall Streets, with an oak desk that was much too neat for anyone who did real work. Ian made an appointment to see Canary, with the intention of asking him, once again, for a raise.

"It's not how big your brain is," Ian argued, "it's what you can do with it. If brain size were so important, then whales and elephants would rule the world, right?" Facts and figures of brain to body mass ratios flitted through Ian's head as he said the words, his lobe instantly retrieving supporting data to back him up, if needed.

Mr. Canary reached up with one hand and smoothed the hair over his enormous head. He was working on his third lobe already, and had selected the biggest, most obtrusive model available. Not that Canary needed a supercomputer in his brain for the type of work he did, Ian mused. Canary was a senior manager, a people pusher, not a facts-and-figures man. His lobe was just for show.

"Ian, I'd like to help you out, really, but you know how the customers are. They all want to know who's handling their money and what kind of a brain they have. The Big Fish want Big Brains handling their accounts."

It was all a crock, Ian thought. Every stinking one of the financial advisers got exactly the same data, the same morning tipsheets, the same recommendations on what to buy and what to sell. Nobody steered a client's assets into pork bellies or Peruvian emeralds because they were smarter than anyone else on the staff. They all recommended the same buy or sell when their data tablets told them to. The whole competition over big brains was just an image

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thing.

"Now, Ian, you're a what?" asked Canary. "An X12a, isn't it?"

An X12a wasn't what he *was*, Ian thought. It was just the model designation of the lobe he had. But he nodded, yes.

"So," Canary continued, "a Big Fish comes in and wants to know who will handle his account. I show him your performance sheet and the first thing he says to me is, 'An X12! Over at Kleinschmidt Brothers, the analysts all have X20's!' So how am I going to convince the Big Fish to move his money here?"

Ian shifted uncomfortably in his seat. It was as if everyone were conspiring to force his hand.

"But I've been doing good work," Ian said. "All my clients are happy with my handling of their accounts. Look how little turnover I've had over the past few years."

"Your accounts are a bunch of comfortable old farts who don't even know what a brain lobe is," Canary said. "They're not going anywhere, except the grave in a few more years. Frankly, you're not one of our top producers."

"But the top producers here are just the ones that have the richest clients," Ian said. "We all have the same information at our disposal and make the same kinds of recommendations. If you steered a few Big Fish my way, then I'd be one of the top producers, and you know it. This is not a matter of who has the bigger lobe—it's a matter of fairness."

"The Big Fish are all young punks," Canary said. "And they are *very* suspicious of anyone who touches their money. They're the ones you have to impress, not me. They're the ones who look at your puny X12a and roll their eyes. How can I assign someone like that to an X12?"

Ian fought the impulse to roll his own eyes, but instead kept his gaze steady on Mr. Canary.

"So, what you're telling me is there's no chance of me getting ahead, no matter how good a job I've been doing, unless I get a new lobe?"

"In a word, yes."

There it was, on the table, no ifs, ands, or buts. Get a new lobe, get ahead. No new lobe, forget it.

Ian and Canary stared each other down in silence for a few seconds before Canary continued, "Look, Ian, my wife tells me there's been some talk at the country club that you may be . . . in some kind of financial trouble. You know, it wouldn't look right to have one of our analysts having difficulty managing his own money, now, would it? And a lot of our clients belong to that club."

"I'm not having any money problems, Mr. Canary. Maybe just a perception problem."

Maybe just a wife problem, Ian thought.

"Good, I'm glad to hear that. But I can tell you that if you did get one of the newer lobes, it would be a lot easier for you to hook some of those Big Fish. I don't have to tell you that sometimes you have to spend a little money to make a little money, right?"

"Uh, sure. I *am* an investment advisor."

"Good. Well, I'm confident you'll make the right choice for you and your family. You have a little girl, don't you?"

"Yeah. Trudi. She's two years old"

"Right. Trudi. I'm sure you'll do what you have to and make her proud."

This was Susan's doing, Ian knew. The witch. Could Susan have stooped so low to enlist his boss's help in using Trudi to make him accept this new lobe? Had everybody but Ian already decided his career path for him?

"Say, did you hear Effie Hunter just got a promotion to full account manager?" asked Canary.

"Effie Hunter?" Ian repeated. "*Effie-who-makes-the-coffee* Hunter?"

"Yeah, and why not?" Canary said. "She knows what the clients want, and she just had an X20c put in. Top-of-the-

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line megalobe. The customers are all lining up to have her manage their accounts."

"An X20c?"

"Absolutely. What a great investment, huh?"

"Yeah, that's, um, great."

Ian wandered back to his desk. His screenwall was lit up with some of his clients' icons, waiting for some face time with him, but he held the calls for a few minutes while he pondered his future.

There, staring at him through a frame on his desk, was a holo of Trudi. Although it was taken only a few months ago, her face had already changed since then, taking on more intelligence and character day by day. That was the reason he toiled here, he reminded himself. How had he gotten so trapped by circumstance into this upgrade, this operation that would plunge him even further into debt? His wife would be no real help; in fact, she would no doubt increase her spending to suck up any increase he did see as a result. So why go through with it at all? What was the point?

The holo of Trudi kept looking at her daddy, following his eyes as he moved around the cubicle. Her little face, so innocent and full of promise.

And Ian knew what it was all about.

He didn't really want Susan to accompany him to the company clinic. No matter how forced into it he felt, it was *his* choice to make, and he already knew where she stood on the matter. But Susan insisted this was a family decision, and they had left Trudi home with Susan's mother while she accompanied him to the clinic.

The lobe technician showed them a slide presentation on the screenwall, displaying the various megalobe models available.

"I think you ought to have the top-of-the-line model," Susan insisted. "The X20c."

"There's no way we can afford that," Ian said, knowing it was that kind of extravagant spending that had gotten them into money trouble in the first place. "I just need something a couple of models higher than what I have to stay current."

"Oh, honey," Susan said, "if you cheap out on this, in a year you'll be behind again, and need another upgrade. Get something that will give you an advantage now, and hold its value a little longer. Come on, Ian, you're an investment counselor—surely you understand the value."

"She's right," the techie said. "The company and the clients want their analysts to have the best brains possible, and you don't want to be back in here in six months looking for another upgrade so soon. You might as well go the full boat and make it last a bit longer."

"But the cost. . . ."

"The company will loan you the cost of the upgrade, and take regular payments out of your salary," the techie said, pointing at the screenwall. "It's all in the presentation."

"OK, OK. If Effie Hunter can become an account manager just on the strength of an X20c, then I know I can outperform her. All right then, let's go with the X20c."

"There's just one thing I have to warn you about," said the techie. "You've still got one of those old X12's. The X20c, and in fact, *all* of the current models are not in the direct upgrade path for the X12 series. Man, your lobe is really old."

"So, what does that mean?" Ian said.

"Well, I see from your records that you've had your X12a for two years now. We can't salvage any memories you have stored in that lobe. The X20c is lightyears ahead, but it's really a full replacement, not an upgrade."

"I'm not sure I understand what you mean about salvaging memories."

"For two years you've lived with that X12 lobe. All artificial lobes are more efficient than organic brains, and they're wired to do the bulk of your thinking

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and remembering for you. We have to swap out the X12 to put the X20 in, and when that happens, you'll lose just about all your memories from the past two years."

Ian made a startled face and looked at Susan, who showed no reaction to the techie's explanation.

"Let me get this straight," Ian said. "I'll have no memory of the last two years? Why would anybody agree to something so drastic?"

"It's only the incompatibility with the earlier X12's that was a problem, and practically all of the people who had those clunkers upgraded them a long time ago. If you'd have come in for an upgrade earlier, like everyone else, there would have been a lot less to lose. It's your own fault for having waited so long."

"But how am I supposed to function at work? I won't remember what the market has been doing or what's up with any of my clients. I've got all the positions of each of my clients stored in this lobe. It would set me back two years' experience at work, when the whole idea of this is to give me an advantage. What am I supposed to do—tell a client I forgot his market positions and financial goals?"

"Hey, I do lots of financial advisers and analysts," the techie said. "Usually what they do is prepare some videos, notes, cheat sheets and stuff before the operation, to bring themselves back up to speed quickly when the new lobe is put in. We tell the clients that you're on vacation for a week while you bone up. Not that much really changes from year to year except the current prices, but you can always look those up. Most of the financial advisers tell me it's a lot easier than it looks. Clients are pretty stupid, you know? No one really notices."

Clients *were* stupid, Ian thought. Stupid to believe that someone with an X20c would really manage his money better than someone with an X12a. Or no lobe at all.

"OK, what about my . . . personal memories?" Ian asked.

"Same deal. Just leave yourself some notes to remember what you need to know."

The past two years weren't all that memorable, what with Susan's growing boredom and dissatisfaction, so that wasn't really much of a problem, Ian thought. But what about Trudi? She hadn't even been born two years ago when he had the first lobe put in. Her whole life would be erased from his memory if he went through with the upgrade. Could he ever write himself enough crib notes to tell himself how much he loved her? Could he describe it vividly enough to replace the lost memory of watching her grow from a tiny seven-pound infant to the sturdy, curious toddler she was now?

The images rapidly flickered through his brain, instantly retrieved by the artificial lobe in response to his merely thinking about it: there was Susan in the hospital, giving birth to Trudi . . . coming home for the first time . . . nursing . . . waking up in the middle of the night . . . changing diapers . . . messy feedings . . . baths in the kitchen sink . . . crawling on the carpet . . . tiny little baby shoes . . . first words . . . walking.

Those memories were priceless.

He was doing this for her. For Trudi. But to do it, he'd have to give up his entire memory of Trudi's short, sweet life. Was there any way this was a worthwhile exchange?

"Don't worry about it, dear," Susan said, interrupting his thoughts. "I'll bring you up to speed on the home front. I'll tell you everything you need to know."

What would she tell him, he wondered? That it was his idea for her to lounge around all day at the country club sipping margaritas and trading gossip with the ladies? That she had sacrificed herself for the family and was now enjoying a much-needed rest while Trudi was babysat in the club's nursery by

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robots?

And how would he even know if she was telling the truth or feeding him total hogwash? With the last two years erased, would he believe her lies? She could tell him virtually anything, and he wouldn't know the difference.

But, in the end, it wasn't the worries about Susan that made the decision. It wasn't the money, either. It was Trudi.

How could he ever think of giving up her memory? The upgrade was off.

Susan was furious on the way home. Slipping into the back seat of the car, she slammed the door behind her, not waiting for Freeman to close it for her.

Ian thought it might be smart to keep his distance and got into the front passenger seat, rather than sit in the back seat with her.

"Where shall I drive the car?" said Freeman, sliding in behind the steering wheel, directly in front of Susan.

"Just get us the hell home," Susan ordered sharply, her voice thick with anger.

"May I suggest a cleaning at Underwood's Car Wash on the way?" Freeman said, as he pulled the car out of the parking lot and onto the city streets. "The shiniest cars in the neighborhood all get their shines at Underwood."

Susan's nostrils flared, and she struck out with the heel of her hand, hitting the back of Freeman's head with a dull metallic clunk.

"Leave the robot alone," Ian said.

"I can't believe you told them no," Susan said, her eyes beginning to fill with tears. "We agreed, dammit. Don't you want to be successful? Don't you want your daughter to be proud of you?"

"If I get the new lobe, Trudi will be a complete stranger," Ian said. "I won't remember a thing about her."

"New Herbal Masquerade Syn-John's Wort is just the thing for better memory retention," Freeman said. "Memories are made of this, with Herbal Masquerade."

"Shut up!" Susan screamed at the robot. "Now, Ian, we're going to go back there and order the X20c, just like we agreed. You can learn to love Trudi again after the operation."

Freeman turned the car onto the highway, headed home toward the suburbs. Ian stared ahead at the oncoming traffic, afraid to turn around and face her.

"What will my friends think?" Susan continued. "Do you want to keep our little girl in poverty?"

Without turning, Ian said, "If she's in poverty, it's because you can't stick to a budget."

"Financial trouble?" Freeman said. "Consolidate your debts and reduce your monthly payments at Barrator Finance Corporation. At Barrator, doodle doo, we want your business bad!"

Ian couldn't help crack a smile. He dare not turn and have Susan see him grinning at such a serious moment, but the robot's advertising was just too relentless and surreal.

Susan, on the other hand, was not amused. She leaned back in her seat and raised one leg high in the air.

"Oh yeah, take this, you insensitive metal prick," she said kicking Freeman with all her strength in the back of its head.

Freeman rocked in the driver's seat, pitching forward and bouncing off the steering wheel, then rebounding back to an upright position. The car swerved and sped up briefly, and Ian's hand dug into the armrest for support as the car narrowly missed a pickup truck before Freeman regained control and straightened the car out.

"What are you trying to do, get us killed?" Ian yelled at Susan.

Susan had fallen over in her seat when the car swerved, and was quietly readjusting her skirt in the back seat. The car sped homeward in silence.

"May I suggest you review your automobile insurance at Impact Insurance Company, where a six-minute call can cover your butt six ways from Sunday," Freeman said.

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"Shut up!" Susan and Ian yelled at the same time.

After a few more minutes of silence, Susan started in again, with a more composed voice, "Ian, honey, not getting the upgrade is just not an option. You *have* to get the upgrade. For Trudi's sake. There is simply no other way for us to get out of this debt."

"The debt we've piled up is not my doing, Susan. It's your fault and your fault alone. We agreed that you could quit your job to stay home and raise Trudi, not lounge around at the country club with rich friends. And they're not really friends if you have to be rich for them to be friendly. We used to get by, just the two of us, didn't we? We can be rich in other ways if you can just remember how things used to be . . . before Trudi was born."

"You make it sound like you wish Trudi wasn't around," Susan said.

"That's not what I meant. You know I would never think that."

"You're not a very good provider for your little girl. You could fix that by getting the X20c."

"Just stop it," Ian said, his voice rising.

"Maybe you're just not cut out to be a father. It's nothing to be ashamed of. Some people just . . . *aren't.*"

"Shut up."

Ian's grip on the armrest tightened again.

"I gave up my career for this," Susan said. "If I had known you weren't going to keep your end of the bargain, I'd have never let you knock me up in the first place."

"Calyptra condoms," Freeman said. "Nothing is safer, but when nothing is not an option, use Calyptra. Available in traditional rolled and new spray packs."

Ian laughed a laugh that was not humorous, and smiled a smile that was not friendly.

"Maybe you're right," he said. "Maybe it *would* have been better for us if Trudi had never been born."

Susan looked startled by the admission, and was speechless for once.

Ian turned away, instantly ashamed he had sunk to her level. How could he have said that, even in anger?

"Mr. Meyer," said Freeman, "perhaps you should contact the Sanctity Of Life Adoption Service, where all lives are precious in His sight and no child is unwanted."

Silence.

Ian stared at the robot for a good ten seconds. In the back seat, a wicked smile broke out on Susan's face.

Ian clenched his fist and raised it in the robot's direction.

"Why, you . . ."

"Oh, he can't help the advertising, dear," Susan said. "It's what he's programmed to do."

Ian frantically began looking for something, anything he could use as a weapon. Nothing on the front seat. Glove compartment, no. There, on the floor was a security club used for locking the steering wheel to prevent thefts. Ian picked up the club and hefted it. Solid, heavy, metal. There, that would do.

"What are you doing—put that thing down," Susan said, shrinking away in her seat.

Ian looked at her, holding the club tightly in both hands. Sure, he could kill her, but it was himself he was mad at. How could he have uttered those words about Trudi? Susan had pushed him into a place he never wanted to go again. They were both guilty, and the arguments would just continue. Maybe the world would be better off without the two of them.

He reared back, then swung the club forward, making a swishing sound as it cut the air, then a metallic clank as he drove it into the back of Freeman's head.

"Don't," said Susan, in a tiny frightened voice.

Freeman's body remained stationary while the head bent forward at an alarming angle, a large depression evident at the point of contact. Ian drew the club back and took another swing, hitting the

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robot squarely on the same spot.

The robot's head popped free and smacked against the windshield, cracking a spiderweb pattern right in front of the steering column. Freeman's body remained upright and motionless, and the car continued in a straight line. For a while.

Ian threw the club down and settled back for the ride, resigned to his fate.

"Ian, quick, grab the wheel," Susan said. "Ian!"

Ahead, the highway curved gently to the left, to avoid a small but deep ravine.

But the car did not.

Ian did not know everyone at the funeral. A lot of the better-dressed ladies, he assumed, were Susan's buddies from the country club. Some of the people, he was sure, were coworkers from the company that he vaguely knew. The day whizzed by, with everyone consoling him on his loss, and wishing the best for Trudi and him. It all blurred together in his memory, although his lobe was recording it all, if he ever wanted to replay it. He doubted he ever would, though.

But he could not help replaying the stored memory of the car crash. His conscience would not let him. The car had landed in the ravine on the driver's side, and the automatic restraints did their work, immobilizing the occupants at the moment of impact. He had survived with only minor injuries—miraculous, considering the other side of the car, the side with Susan and Freeman, had been sheared away and mangled into unrecognizable shreds of metal and glass . . . and flesh.

That wasn't how it was supposed to have ended. In the heat of the moment, Ian had fully expected to die along with Susan in the car. That would have been fair. But now that he was still alive, how could he go through with it and kill himself? Trudi would be an orphan.

At one point during the funeral, Mr. Canary cornered him to say, "Sorry about this, Ian. It's a terrible tragedy. Take all the time you need. We'll talk when you get back to work."

But Ian wasn't so sure he *would* go back to work. He certainly didn't need to work, ever again, if he chose not to. The Freeman Robot Company had instantly offered him a huge settlement worth many times his projected lifetime income, just for signing a piece of paper that said he would not seek any further compensation, nor incriminate the Freeman Robot Company in the media. Nobody wants to buy a robot if they think it might kill them one day, and Freeman Robots didn't want the bad publicity of a trial. They paid handsomely for his silence.

With all the settlement money, and no Susan to nag him, the megalobe upgrade wasn't needed anymore, either. He didn't need the lobe, the job, the promotion, the money. Nothing. None of it. He was set for life.

He was a Big Fish.

There was just Trudi and him, now. The two of them, living modestly, perhaps, despite all the money in the bank. The way it should have been, not the way Susan wanted it.

Except Trudi had no Mommy.

Ian's mother-in-law brought Trudi into the room where the funeral service was held. Trudi was obviously afraid of all the strangers looking intently at her, and the unfamiliar room with all the flowers and candles. Ian peeked through his hands as they went up and touched the closed coffin.

"I want my mama!" Trudi cried, loud enough to hear throughout the whole room. The child didn't associate the bronze casket with her mother, didn't understand that she would never see her mother again; she was just frightened by the strangeness of it all and wanted to be comforted.

"I want mama!"

A tear, for Trudi, slipped down Ian's cheek, and he walked to the front of the room to get her.

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Ian had tried to explain to Trudi how the bad robot didn't work right and made a boo-boo. How she wouldn't be able to see Mommy for a very long time. But kids at that age just don't understand about death yet. There would be more time.

"Dada, I want mama!" Trudi said, as she recognized him coming forward.

There would be more time. Time for him to think about what he had done. With an artificial lobe that would not let him forget even the tiniest detail. How he had committed murder and gotten away with it. Turned his precious Trudi into a motherless child. Killed his Susan. His beloved Susan. He *had* loved her, once. Not that long ago, actually. He knew he should turn himself in to the police, come clean and take his medicine for killing Susan. Maybe even kill himself and finish the job. But what then of Trudi?

Ian picked her up and hugged her hard. Bringing a two-year-old to her mother's funeral had been a stupid idea, Ian realized. They were both crying freely as he carried her outside.

After the interment at the cemetery, Ian went home and recorded the video.

Ian opened his eyes to unfamiliar surroundings. Oh, yes, now he remembered. The company clinic. Where, if everything had gone as planned, he should now have his new artificial brain lobe. It was just as he and Susan had planned, so they could afford to keep her home from work when their first child was born.

He reached up and felt the new bulge on the back of his head. Yep, just where it should be, his new lobe, although surprisingly larger than he imagined it would be. His state-of-the-art X12a lobe.

A robot nurse entered the room and looked him over. It was some new model robot that Ian had never seen before.

"Mr. Meyer, you are awake," the nurse said. "How are you feeling?"

"A bit groggy. Like I've been out a while. Is my wife here? Susan is her name. I want to let her know everything is all right."

"Your . . . wife?" the nurse said. "There is a video you should see to begin your orientation. Select program number one on the screenwall menu."

Ian thanked her and the nurse left the room. He guessed video number one would contain some tips from the factory for operating his new lobe. "Using Your New Brain," or something similar. He voice-commanded the screenwall to begin playing the video.

Instead of some factory geek, it was his own face that greeted him from the screen. A face that looked a few years older and wearier than the one he remembered from the mirror.

"Hey, buddy, I hope you're lying down for this, because I have some important stuff you need to know. There's some good news and some bad news.

"The bad news is that Susan is dead. She died in a car crash a little over a week ago. When I think back to where I was two years ago . . . where you are right now . . . I know this is going to be really painful. I'm so sorry for you."

Ian's jaw dropped. Susan dead? His darling Susan? How could it possibly be true? Maybe it was some kind of weird test for the lobe, he hoped. But that was *himself* on the video telling him so matter-of-factly that Susan was dead, like he was reporting that the Yankees had dropped a double header or something. He would never have agreed to such a cruel hoax . . . unless it was true.

"The other bad news is you've lost two years of your life," the screenwall said. "This brain lobe that you're feeling in the back of your head is not your first lobe. It's your second. The first was OK, but times change and you needed an upgrade. Unfortunately, all your memories of the past two years have been erased. I'm sorry for that too, but it's just as well. It's better that you don't remember some things."

Two years' memory gone? This really

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must be some kind of cruel joke, Ian thought. The whole point of getting a lobe was to increase his memory and reasoning. Why would anyone get a lobe if it *erased* memory? What kind of a scam was this if he couldn't remember anything?

"The good news is that money is not a problem," his face on the screenwall continued. "The accident that took Susan's life was settled generously, and you don't have to worry about that ever again if you play your cards right. It was quite a blow to all of us when Susan died. She was such a great lady, and you loved her right up to the end, just like you do now.

"The other good news is you're a daddy. It's a girl, and her name is Trudi."

A photo of a smiling toddler was displayed on the screenwall. A pretty little thing she was, with blond hair and dimples. Looks a lot like her mom, Ian thought.

"And what a great little kid she is," his video image continued. "You're gonna love her just like I love her. Don't worry that she's a stranger. It won't take very long before she finds her way into your heart. Just love her, and everything else will work out OK. She's your little angel."

"My little angel," Ian repeated.

"And that's all you really need to know," the video said. "There's been some bad times, but I think this upgrade is really going to work out for us. It's not just your brain that's been upgraded, but your life, so go have a great one. See you in the mirror."

The video ended, and Ian's jaw hung open. Two years? Susan dead? A two-year-old daughter? It was overwhelming.

Ian thought about the video, and his megalobe mentally replayed it for him again, the images and sound appearing in his brain exactly as it had played on the screenwall. Sixteen times in a row he replayed it, each time digesting and assimilating a bit more, until it was burned into his original, organic brain. How would he get by without Susan? And now with a kid to raise all alone.

Why didn't he understand everything? Wasn't the new lobe supposed to make him think better? He was about to run the video in his brain for a seventeenth time when the robot nurse returned.

"You have a visitor," the nurse said.

It was Susan's mom, and a little someone else. The little girl from the video. Trudi, her name was.

"Daddy," she called.

She was even prettier than the picture in the video, Ian thought. Already, he was beginning to understand.

"My . . . little . . . angel," he replied.□

Human alterations of the environment do not (yet) compare with such feats of nature as the moving of a continent or even thecreation of the world. But we have been at it for a very short while.

—Michael Bell

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THE GREAT GRAVITY DEBATE part I

Back in June of 1997, I published a fact piece in *Analog* called "Paradigm Shifty Things." One of the potential paradigm shifty topics that I discussed dealt with the speed of gravity and how some ways of looking at the data suggest that gravity propagates at billions of times the speed of light. Though the part about gravity was only one of several in my article, it was the part that generated the most debate. Once the mail started coming in, I decided to look deeper into the controversy, and found it to be a good deal more complicated than I'd thought. I promised that sooner or later I would write at greater length about what I found. This column, and the one to follow, are my attempt to fulfill that promise.

One ongoing tension I have when writing this column is trying to decide which topics I can handle adequately within the space requirements. I put off revisiting the gravity debate for some time, in part because I couldn't decide if I could do the topic justice in a pair of Alternate View columns. There was always the possibility of covering the material in the form of another fact article, but I have other topics I'd rather address that way since those will absolutely require diagrams and equations.

While I was making up my mind, Internet access continued to expand, the question of the speed of gravity continued to be debated in various online forums, and a variety of technical, journal-quality articles on the topic came to be just a URL away. This has made my task easier. Now I don't have to write too extensively about the subject; I can just serve as a guide, helping you to understand the nature of the debate and giving you a heads-up to the sorts of arguments you'll come across as you look into this business yourselves.

First, a bit of personal history.

The scientist who brought the speed of gravity controversy to my attention was Dr. Tom Van Flandern, and it was his views I discussed briefly in my *Analog* fact piece. Among the people who later wrote letters saying, essentially, "Van Flandern is wrong", was Dr. Steve Carlip of UC Davis. Now Van Flandern is a professional astronomer with the same sort of *curriculum vitae* as anyone else who might publish in the conventional respected literature. However, Carlip is also a professional scientist, and his expertise lies in the field of quantum gravity. He is no slouch when it comes to knowing just what General Relativity does and does not say. Van Flandern and Carlip had debated before to some extent in various Internet forums. But as Van Flandern put it in the acknowledgments section of one of his gravity papers [1]: "[Jeff Kooistra's] *Analog* article (Kooistra, 1997) flushed this subject to the forefront once again, and his inquiries to both Steve Carlip and to the author forced us to explain our positions in layman's language, and thereby diverted us from talking past one another."

What Van Flandern was referring to is the debate that he and Carlip had via e-mail through my computer, with me as something of a moderator. Those back-and-forth e-mails would run on for pages, resulting in a stack of hard copies that's four or five inches high. When the debate

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began, I had expected it would go on for a few exchanges, then I'd write up an article about it. But the discussion continued and I kept learning more and more about how ignorant I really was about the subject. While I was learning, Van Flandern and Carlip were honing their arguments. The result was that they produced their own papers long before I could.

In the years following the publication of "Paradigm Shifty Things," I had the opportunity to meet Dr. Van Flandern in person. I found him to be a gentle, soft-spoken man, with a genuine passion for getting at the truth. I did not get to meet Dr. Carlip, but I do feel I came to know him somewhat via the debates. He does not fit the mold of the "crusty establishment scientist" that some in the alternate physics circles might think (anymore than Van Flandern fits the mold of the "wild-eyed, anti-Einstein" kook). Indeed, I found him refreshingly willing to discuss openly the speed-of-gravity matter. Dr. Carlip cares about truth, too, or he wouldn't have put into the debate the time and effort that he did.

So, what *is* the debate all about? I'll finish out this column with a discussion of why the speed of gravity must be much faster than light, and in Part II explain why the conventional view says otherwise.

I can state in one sentence why some would think the speed of gravity is faster than light. Here it is: *Because Newton's equations for gravity treat gravity as an instantaneous force and they work damn well for whatever gravitational problem we apply them to.*

That's it. Newton's theory of gravity works just fine to send space probes to Luna or Mars, or to do multiple close approaches to the Earth to pick up the needed speed to reach Jupiter and beyond. Also, to conserve angular momentum, Newtonian gravity absolutely requires that the speed of gravity be infinite. I have seen it wrongly argued that, since the speed of light is so fast, if we just put a lightspeed delay into Newton's equations, we'd never notice the difference. But as Carlip points out in one of his papers, "Putting a 'light travel delay' (technically called 'retardation') into Newtonian gravity would make orbits unstable, leading to predictions that clearly contradict Solar System observations." [2]

So there is no disagreement on this point between the General Relativists and Van Flandern—stick a lightspeed lag into Newton's law of gravity and the Solar System will fall apart. Since this doesn't happen, to Van Flandern, the implication is obvious—the propagational velocity of gravity must be far faster than light.

But Carlip and others would tell you that Van Flandern's "obvious" implication is model-dependent. Here's what that means.

Consider the Earth in orbit around the Sun. The Earth's velocity is about 30 kilometers per second. A photon leaves the Sun, travels for a little over eight minutes, then reaches the Earth. An observer on the Earth sees the photon, sights back along the path the photon took, and sees the Sun, but not in the Sun's real "God's-eye-view" instantaneous position. Rather, the Sun's position will be shifted by about 20 arcseconds. That is to say, the light from the Sun will be *aberrated* by an amount directly proportional to the Earth's orbital velocity. Don't confuse this with the fact that we see the Sun eight minutes younger than she "really" is. If the Earth were not moving with respect to the Sun, then the Sun's optical and the instantaneous positions would coincide even with the time delay.

Now consider the gravitational force. Although Newton set his laws in an empty space and assumed instantaneous interaction between bodies, he abhorred the idea that two bodies could interact with each other without something going back and forth between them. However, not knowing what that something is, Newton left it up to his readers to worry about. Today it is customary to assume that some kind of particle exchange takes place between bodies when they exert forces

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upon each other, and it is also customary (and usually mandatory) to assume that those particles can travel no faster than the speed of light.

Going back to the Earth orbiting the Sun, let's follow one of these hypothetical force particles (I have good reasons for not calling it a "graviton") that's emitted next to that photon we talked about before. Since it's moving at the speed of light, it must be taking the same path as the photon. When it gets to Earth, it must also be aberrated just as much as a photon would be, since the aberration is the result of the *Earth's* motion. When the photon hits the Earth, it imparts its teeny bit of momentum to the Earth. Because of aberration, this momentum has a tiny vector component antiparallel to the Earth's motion, so the Earth is slowed down a teeny bit. When the force particle hits the Earth it signals attraction, in essence saying "feel a tug this way from the direction I came." But then the Earth would be responding to the force particle as if the Sun was at its optical position. This would give the Earth a tug not just in the direction of the Sun, but also a tiny bit in the direction of its orbit, hence speeding it up. Over time, the Solar System would fall apart.

Yet the Solar System is a fairly stable place. The Earth really does feel the Sun in the direction of the Sun's instantaneous position. In Van Flandern's model, the easiest way to explain this is to simply say that the force particles travel far faster than light, and hence are far less aberrated than are photons. Van Flandern figures they'd have to be moving at least 10 billion times faster than light.

There's one other little point that needs to be addressed—exactly *how* does the force particle tell what it collides with to "feel a tug" rather than to feel a push? It's easy enough to understand how a photon could give the Earth a little push—we see that sort of thing all the time with billiard balls and bullets. But what kind of bullet would hit a target and make the target recoil in the direction the bullet came from? A simpler particle model of gravity would take the chore of emitting force particles away from material bodies altogether. Instead, one can fill space with zillions of tiny particles that zip throughout the Universe at billions of times lightspeed. These impact with matter and give it a little push. That which we call gravity happens because of shadowing. For instance, in our Sun-Earth model, the Sun would slightly attenuate the particle stream heading toward Earth from the direction of the Sun (and vice-versa), producing a zone of reduced particulate pressure between the Sun and the Earth. This would look like gravity. Van Flandern has sorted out many of the details of this "pressure model" of gravity (which he calls the META model), and you can read about it in his book *Dark Matter, Missing Planets, & New Comets*.

Even Carlip would admit that Van Flandern's simple particle model would require those particles to move FTL to avoid the effects of aberration. But he'd also argue that General Relativity models gravity in a much different way than the one Van Flandern likes. That model does limit gravity to the speed of light, and the aberration question is treated differently. [3]

Stay tuned for Part II.

References

[1] This can be found in the paper: "The Speed of Gravity—What the Experiments Say" by Tom Van Flandern. It is posted at *http://www.metaresearch.org* along with several other papers on the same topic.

[2] This can be found in the paper: "Does Gravity Travel at the Speed of Light" by Steve Carlip, Matthew Wiener, and Geoffrey Landis. It is posted at *http://math.ucr.edu/home/baez/physics/grav_speed.html*

[3] A debate on the subject of the speed of gravity which is very much in the spirit of the debate I moderated can be found at *http://www.math.washington.edu/~hillman/PUB/debate* and *http://www.math.washington.edu/~hillman/PUB/debate2000* ■

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A Moment of Integrity

Jeffery D. Kooistra

Illustration by Vincent DiFate

Nature doesn't keep secrets, and people can't forever—but sometimes they must, for a while.

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Being careful not to hole his suit, Jerry pulled a large section of wrinkled sheet metal out of the wreckage, the Martian sands sliding off and swirling away in the thin breeze to reveal a black swastika.

"What in the hell did we just find?" Denise muttered. "Captain," she said to me. "Correct me if I'm wrong, but Germany didn't send rockets to Mars during World War II, did it?"

"Not that I'm aware of," I said calmly, though I was as taken aback as she.

Jerry put down the piece of metal and continued to poke through the junk from the crash. "This thing used vacuum tubes," he said. He tossed a piece of junk my way. It contained some broken tubes, bulky resistors and capacitors, and a few other bits of museum electronics.

"Maybe they sent some kind of unmanned probe out once. Would have had to do it in secret, of course. That's why we've never heard of it," I said.

Jerry stood up holding a human skull. "Nix the unmanned part," he said.

Ours was the fourth manned mission to Mars, or maybe the second, depending upon how you look at it. The first two missions were "crewed" by two women and two men each, but that had been over thirty years ago. What with the Big Spasm of 2016, the thought police found they had more important things to do than worry about the English language and politically correct usage, so the third mission and ours were once again "manned" missions, even though four of the eight of us were women.

The Big Spasm had been a hideous thing for the entire Earth, yet some good had come of it. Things had become so shaky anyway by the time the bombs dropped that billions died of disease though only a few capitals were actually annihilated. Institutions collapsed, multinational corporations imploded, and even some countries ceased to exist as anything other than place names on a map.

But after it all settled down in the old USA, and the survivors reorganized, it was decided that a return to Mars was needed.

Odd? Yes, perhaps. But we needed a goal, a something to achieve, a symbol that would say, "We're back to where we were before." This wouldn't be true, of course, but symbols don't always need to hold up under scrutiny to be meaningful.

So we went back to Mars, though not the same way as before. That had been a clunky way, a bureaucratic way—the "please-everyone-a-little-bit-but-no-one-very-much" approach. No, we went back to some older ideas that had been tossed aside in the name of progress. We pulled an old Saturn V out of the Apollo junkyard and went over it with calipers and micrometers. We learned how to build such space skyscrapers again. Oh, we stole technology from all over the twentieth century and the first years of the twenty-first. What had worked well in the past, we used—that was all that mattered.

The goal was huge—huge enough to employ millions. The symbol was grand enough to make their hard work worthwhile. Working together, millions were educated, millions learned the skills needed to make a high-tech world work. For those who could engineer and build rockets could engineer and build anything.

It felt good to be captain of the fourth Mars mission, I'd been thinking as I stood in my suit staring out at the rocky plain. It was then that I'd noticed the glint of sunlight off of something out a few hundred meters from our landing site. I took Jerry and Denise along to investigate, and we found the crash.

After an hour of poking around, we selected a few things to take back with us. Vicky helped us out of our suits when we went back inside the lander. She was the only one there—the other

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four under my command were off on an exploration trip in the rover.

"I was listening in on your conversation," she said as she pulled my helmet free. "A crash site of some Nazi something or other. Amazing! So Hitler's men beat us here by a hundred years. I guess this means we're really the fifth mission to Mars."

"Why not the sixth or the seventh?" I said, pulling my arms out of the suit sleeves. "Hell, maybe this is where Hitler really went and not South America after all."

Jerry held up the skull he'd found. "Hmm. Doesn't look German."

Denise looked confused. "Hitler committed suicide in his bunker just before Berlin was captured," she said.

"That's what *you* think!" Vicky and I said in unison, then we laughed. Vicky and I had met as graduate students just before the Spasm. We'd both been doing doctoral work on twentieth century paranoid literature. We'd married just before the world came apart. Now we were on Mars together, two former English Ph.D.s. Go figure.

"For years it was thought by quite a few people that somehow Hitler had really escaped Berlin and managed to sneak off to Argentina where he was planning his return to power," I explained. "After the Soviet Union collapsed in the 1990s, scores of people combed through old records trying to find out if the Soviets knew more about what had really happened to Hitler than we did. Some people were still looking for Hitler even after he would have been a hundred years old had he lived."

"What do you *really* think?" Denise asked.

"He committed suicide in the bunker," Vicky said.

I looked at another piece of metal I had in my hand, something much smaller than the sheet with the swastika. This bit had an ordinary, but noble, *Luftwaffe* black cross. I shrugged. "I think I still believe that, too."

* * *

The next day the four of us were back out at the crash site. We wanted to recover and photograph as much stuff as we could before sending a report back to Earth. Our credibility was at stake, and that was particularly important since the rover crew was on the way to Cydonia to see whether or not the Face on Mars was natural or artificial. (God, the paranoid part alone of the literature on that debate could have kept a person busy for a lifetime!) So we didn't want to just up and tell our superiors that we'd found a crashed German rocket from World War II.

We had the tractor with its attached trailer out there with us. It didn't take us too long to find two more skulls and a bunch of bones with tatters of dried flesh still attached. Clearly, the people who'd made the trip had not survived the crash.

"What if this is just some kind of hoax?" Jerry said at one point. "I keep thinking about the technology needed to get to Mars. Hell, we stole the best stuff from fifty years worth of space work just to make it back here as soon as we did after the Spasm. It seems impossible that the Germans could have done it while fighting the war at the same time. Why would they have wanted to? And how could they have kept it secret?"

"Kept it secret? That's easy," I said. "Compartmentalization. The right hand doesn't know what the left hand is doing. Hell, usually, the right hand doesn't even know there *is* a left hand."

"It would have come out," Jerry insisted. "You could never keep something like that a secret, Captain."

"You couldn't keep it a secret forever," I agreed. "But few secrets need to be kept that long. Suppose there was a secret project to build some super-duper flying contraption. Maybe Hitler knew about it. Maybe there was no one in between him and the three men that belonged to the skulls we found. Everyone

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else who worked on this thing might have only worked on a single piece of it; all of them unaware of what the whole would look like and what it would do once all the parts were together. After Hitler dies and these three buy the farm here, who's left that has the whole story? Sure, parts of the tale will survive as stories that grandpa used to tell the grandkids. But with the records lost to the destruction of the war and the only craft to know flight lost on Mars . . ." I trailed off there, the point made.

"But what about the technology itself?" Denise asked. "Regardless of whether or not they could have kept the secret, how could they have made it here? I haven't seen anything that looks like a rocket nozzle yet. In fact, I don't think this thing looked like a rocket at all. All we've got is a lot of vintage electronic gear from the museum junkyard, and a shitload of this wire." She held up another of the hundreds of oddly-wound coil units that were in the wreckage.

"OK. So what is your alternative hypothesis?" Vicky asked before I could; though she did mimic my voice and I saw her smiling at me from inside her helmet.

"Like Jerry suggested, a hoax," Denise said. "From before the Spasm. People would have been too busy after the Spasm to waste time with something like this. But think of it as a high-tech version of the Piltdown Man hoax. Only this time, for whatever reason, someone wanted to supply false evidence that the Germans had made it here first. In fact, maybe the Germans really did do it. There was a big push for a renewed national spirit about twenty years after the German reunification."

"I've never heard of that," Jerry said. "But I think I like where you're going."

"My mom told me about it. I was born in Germany around that time. Perhaps they put this thing on Mars in secret and were planning on having it found by one of the Mars missions sooner or later. The find would have been symbolic of German technical prowess or some such. Then the Spasm came and the idea was forgotten. Then what we have here really *is* period-piece electronics, but it came via rocket and was just dropped onto the surface. A few dead bodies were included with the payload, and these coil thingies are just window dressing."

I'd kept digging through wreckage while Denise talked. Pipe fittings, more coils, a pocket watch. The watch I slipped into my pouch without mentioning it—it looked like it was gold and I noticed that "*Ich liebe dich,* Berlin, 1939" was engraved on the back.

"Not a bad theory," I said. "But it has a few problems. If this were done for propaganda purposes, it would be impossible for the fakery to be kept quiet once the find was made public. Other non-Germans would have gone over the crash site and they would have uncovered the hoax in relatively short order. Then you'd have the perpetrators being vilified for wasting so much money on such a silly scheme. Another problem is the swastika. Even just before the Spasm, the last thing Germany wanted to do was highlight its Nazi past. There were just too many neofascists waiting around. Unless you want to assert that one of those groups might have had the wherewithal to pull this off. So if it was a government-subsidized hoax, we would have found the usual *Luftwaffe* crosses, but there would not have been a swastika in sight."

"But Captain," Jerry said. "If this is genuine, it would mean that the Germans really did have an advanced flying capability—hell, advanced spaceflight capability—back at the end of the war. Better stuff than we're using. Better stuff than before the Spasm. Look at all these coils. Are we talking advanced electropropulsion here? Why didn't they use it to win the war if they had it? Denise is right. I haven't seen a rocket nozzle anywhere either."

"They built only one prototype. Here

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it lies, crashed on Mars in her maiden flight. That's why they didn't use it to help in the war."

"But why to Mars, dear?" Vicky asked.

"Mars, the god of war. Because it was symbolic. And maybe it was only going to take a day or so for the trip. If we're giving them advanced technology, we might as well go whole hog."

By now, Denise was positively annoyed with us. "Advanced flying capability or not, electric propulsion or not, what did they use for a power supply, Captain?"

Ironically, just as she asked that, there came a very faint clink, wafting through the thin air when the shovel she'd forcefully thrust into the ground hit something metallic and unyielding. After swearing in surprise, Denise uncovered some more of the thing, then called us to help as it proved to be quite large.

We stared at it once it was clear.

"This answer your question?" Jerry asked Denise.

"I can't *stand* it!" she said.

It was a diesel-electric generator, vintage 1944. There were a lot of German words written on the housing, and the intakes had been modified to allow bottled air to be delivered to it while operating away from atmosphere.

"Well—" I began, but Denise cut me off.

"That's enough, Donald!" she snapped. I don't even think she noticed she didn't call me Captain. "The energy density of diesel fuel is too low. No way in hell did they use diesel fuel to get to Mars!"

"Diesel electric," Jerry said, trying to be helpful.

"Shut up!"

"Don't take it so personally, Denise," Jerry said, trying not to laugh. But Denise just huffed and stomped off.

Vicky looked at me and I at her. I nodded. We were both recalling the same thing—the weird-science literature that was a subset of the paranoid stuff. It was riddled with bits and pieces about suppressed technologies, enigmatic energy machines, and electrical devices dating all the way back to the 1800s that seemed somehow to cheat the Universe and suck extra energy out of the very wheelwork of Nature.

But what an enormous amount of energy it would have to be! A tank full of diesel fuel and that generator would get you to Mars, even after lifting off from the surface of the Earth? Our Saturn-derived rocket was the equivalent of a slow hydrogen bomb explosion in terms of the energy needed to get us here. And here the Germans had made it with no more fuel than would be needed to drive a truck from Berlin to Paris.

We took more photos. Denise came back and continued digging. We loaded more parts into the trailer and took them back with us. I video-recorded everything. We returned to the lander and then it was time to try to figure out what I was going to say in my report.

I still hadn't figured out what to say by the time Vicky joined me in bed. She cuddled up next to me and read my mind. "Can't figure out what to tell them, can you?" she said.

"No. There aren't that many people like us who've studied the right literature to even know this crash was a faint possibility. I'm afraid they'll just think we're all crazy, maybe tell us to go check the oxygen mix."

"But isn't it exciting just the same, Don? Remember how we used to read all that stuff and wonder how much of it—if even any of it—was true? All that circumstantial evidence about secret government agencies, and testimony about how some men in black suits showed up and took some hapless inventor's secret energy machine away."

"Yes, it was exciting," I agreed. "We were younger then."

"I don't know—I'm feeling pretty young right now in this gravity," Vicky said while employing a familiar, welcome, and erotic touch.

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We made love then in the soft Martian gravity, and for a time my mind went back to Earth, then to the stars, then back to Mars again. Vicky lay quietly beside me, but my brain kept spinning at high RPM.

"Vicky, I want to show you something." I retrieved the watch from the nightstand drawer. She took it from me. "What do you think?" I asked.

"Nice watch," she said. She closed her eyes and held it to her. "Very much cherished by its owner. His wife gave it to him."

Vicky believed she could read impressions from objects. She had gone into the study of "weird lit" seeking validation of her talent. I'd gone into the same field looking for a mundane explanation for the unreasonably "lucky hunches" I'd had during my life. We made a good team.

I couldn't stop thinking about those "secret government agencies." The really secret ones that no one not in them was even supposed to know about, not those that were known, but just did secret stuff. "Absence of evidence is not evidence of absence," it has been said of alien life, still sought, still unfound. Couldn't the same saying apply equally well to secret agencies and societies? Ah, but there *was* evidence. I'd read hundreds of books of evidence. But such societies counted on a deeper, ironic truth, to maintain themselves. "The presence of evidence is not evidence of presence." At least, that's how it worked for most people.

The governments before the Spasm had been pouring billions of dollars into black programs for decades. What had that money bought? One thing was underground bases, perhaps even cities. Public records indicated that some labs had been constructed with fifty or more underground levels. But what was on those levels? Those records I'd never found.

Billions and billions of dollars—more money than the GNP of most nations on Earth. Those bases would be pretty robust concerns in their own right.

Had they survived the Spasm?

Ultimately, I fell asleep, and when I woke, I knew what I'd do.

It was supposed to be a major live report, completely open to the public in real time (well, not counting the light-speed delay of our transmission). I had not clued control in to our find. I could have warned them, or at least asked their advice.

But what if someone else listened in?

The signal came that the Earth was ready for our transmission. I started the video rolling of the crash site while speaking into the microphone, my words going out as a voice-over narration.

I told them what we'd found, of my ideas of how this could have come to be. The visuals of the swastika were particularly arresting. What would the Earth make of this?

I went on for twenty minutes before I noticed the return transmission from control. "Signal lost at 00.00.14." Earth had seen only the first 14 seconds of my broadcast before the signal was lost.

Or interrupted.

Oh, shit.

A couple of hours later, I wasn't surprised to see the flying saucer come over the horizon and hover near the lander. Silver and black, the saucer was actually a rounded-off triangle, with no identifying markings whatsoever. Jerry, Denise, and Vicky watched with me. We speculated in fear and fascination about who or what might be aboard. Finally, it opened up landing gear, very ordinary tires on a frame just like an airplane, and settled to the sand.

They hailed us. "Captain Kohl, we'd like you to come over and see us. Alone, please."

"At least their English is good," Jerry said.

Vicky looked at me. "Don?"

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"I don't think I can tell them I'm too busy," I said. "Help me into my suit."

Maybe being commander of the fourth Mars mission wasn't so great after all, I thought as I walked slowly toward the flying saucer. I was aiming for the small staircase nearly hidden from view in the midst of the landing gear. It looked so ordinary. I started up the stairs and then entered an empty room. The stairs rose up behind me, a panel slid over the opening, and I heard air hissing around me. Another minute passed, then another panel slid aside and a man, sixtyish, walked in and helped me remove my helmet.

"I'm Max," he said. "You'll be here for a couple of hours. Come with me and we'll get you out of that suit. Would you like a drink?"

A short time later I was drinking a scotch and water and sitting in a circa 2005 Steelcase office chair.

"Sorry we had to block your transmission," Max said. "We watched it here on the ship, though. It was quite good."

"Thank you, I think. So what's next? Kill me and my crew?"

"No. If this were a matter of that kind of importance, we never would have let your rocket take off from Earth. Right now you'd be suffering through yet another interminable delay, at home, waiting for the 'problem' to be fixed. But—well, here you are."

"So it's all true," I said.

"'All true?'"

"The stories. About the secret agencies and the hidden and suppressed technologies."

"Oh, that. No, not all true. Some. Most of those stories are crap—some of it deliberate disinformation, but most of it generated by both the true believers and the knee-jerk debunkers. You get about an equal amount of garbage from both."

"I don't suppose you'd be willing to tell me what parts aren't crap?"

"For most of it, I don't know any better than you do."

"Compartmentalization?"

"Bingo."

"So what *are* you going to do with us?"

Max took a sip of his own drink, which I think was just mineral water. "We're going to let you go. We'll leave you with some of your video data. You can even keep some of the wreckage. None of the coils, though."

"Why not the coils?"

Max seemed to think that over. "Those tend to point a little too clearly to just exactly where physics got off on the wrong track," he finally said. "Or so I've been told. That information isn't in my compartment."

"But the idea is that you can't let the babies play with the gun?"

"Essentially. But you're not considered a baby, Captain, I assure you. We come into contact with a lot of them, though."

"So what gives you the right to decide who is a baby and who isn't?" I asked, forgetting for a moment that I was on his flying saucer. I'd had that question in mind for years when I was studying the paranoid lit. I wasn't going to miss the chance to ask it.

Max didn't get angry, though. "It's not a matter of 'rights', Captain. It's a matter of duty. If you saw a child about to fall off a balcony, would you argue over whether or not it was your right to interfere? In certain situations, situations that sometimes come about by chance, there are certain responsibilities that every decent human being accepts as being there."

"Yes, but—"

"No 'buts'," he said. "I didn't wake up one morning and decide I wanted to withhold information from most of the human race. My duties were handed to me at an early age. I didn't choose them.

"Now let me tell you how that wreckage came to be on Mars. That's what my duty is at the moment."

I was certainly curious about that so I sipped at my drink and gestured for him to start.

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"It was clear to the Germans by the middle of the Second World War that they couldn't win without some kind of technological breakthrough. They adopted a shotgun approach to scientific research. They combed the literature for weird ideas, and particularly for strange experiments that had yielded peculiar results. They interviewed hundreds of cranks. Only a few of them were not cranks. One of these was Otto Klein.

"Klein had a device with strangely wound coils that folded back on themselves, and when he ran the thing, it threw sparks and more often than not, simply blew fuses. But three times out of ten it would make a bar of a special metal alloy levitate.

"A lab was provided, and lots of help. Germany still had a great many top physicists. They and Klein worked out the implications of the new wrinkle in electromagnetic theory that the Klein device exploited. Workers from the aircraft industry were brought in. Parts were fabricated. In the end, they produced a flying machine.

"Klein and two others took her out for a test flight. From the official records, we know that they were only supposed to fly up ten kilometers, then come back down. This was in February of 1945.

"They didn't come back down."

"So that's the crash out there—Otto Klein and crew? Why Mars? Why did they do it? Or doesn't anyone know?"

"*Know?* Not for sure. All that we have is what was in the note Klein wrote to his wife the night before his departure, and that he left with a friend to give her later.

"The other two with Klein were Schmidt, who'd become his right hand man during the project, and an unidentified SS man with a gun. Klein wrote that the 'weapon' they'd constructed was too terrible to give to Hitler. And Schmidt agreed. There were only two seats in the ship. Klein and Schmidt would have been seated in the pilots' chairs. The SS man would have been standing up and guarding them. Klein understood the kind of propulsion system he had. Can you say 'right-angle turn'? Once at altitude, they bounced the SS man from bulkhead to bulkhead with high-gee vector changes. There's actually a telephoto movie taken from the ground of that. And then the craft took off.

"Why Mars? Klein wanted to see it. They had to crash the craft somewhere, and Klein knew they could make it in a couple of days. And even if they missed Mars, at least the ship would be on a course for the stars."

Max stopped, took another swallow of his drink, and sat there with a fractional frown on his face. I thought he was going to continue, but he waited until I finally asked the obvious question: "So why tell me this?"

"Secrets can't be kept forever," he said. "You know that—you discussed it at length in your doctoral dissertation." He smiled when he said that.

"You read *that?*"

"Sure. Yours, and several dozen from the other potential commanders of the fourth Mars mission, who might have been here instead of you. It was a matter of filtering, positioning, and of increasing the odds in our favor."

"The odds of what?"

"Of letting the secret out slowly. The technology we're protecting is dangerous, but Otto Klein caught on to it over a hundred years ago. Like him, we're both buying time before the secrets come out, and trying to prepare the world for when they do."

"The secrets are that dangerous, eh?'

"Think about it."

And I did. Diesel electric power to start, then free energy from the "wheelwork of Nature". Max had said they'd made it to Mars in a few days. So significant fractions of light speed were attainable.

Crash something moving that fast into

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a city . . . Hitler would not have needed the bomb.

"OK," I said softly. "I understand."

"So did Otto Klein, ultimately," Max said. "That ship was the culmination of his life's work. But in a moment of integrity he realized he'd been born too soon."

Max stood. "You can go now."

"That's it?"

"Yup. We've already taken from your crew what we can't let them keep. If it's any consolation, the rest of your crew is going to find some pretty interesting stuff at Cydonia."

"But what am I supposed to tell my superiors?"

"Anything that you think prudent," Max said. "If you want to tell them that you just spent the last hour with some flying-saucer people, that's fine with me. A few of your superiors already know."

I could only smile at that. I suppose I could have felt angry that people behind the scenes had manipulated my life. But the truth was, they hadn't—not really. It was more a matter of nudging.

Before I left I had one more question I wanted to ask Max. "How did you get into this?"

Max didn't hesitate. "Otto Klein was my grandfather. He married my grandmother in 1939, but after the honeymoon he hardly saw her, or my father when he came along, what with the war and everything." Max smiled. "What kinds of secrets does your family have?"

1939? "Were they married in Berlin?" I asked.

"I believe so, yes."

I'd had a hunch before I went over to the saucer. I fished the watch out of my pocket. "I guess this belongs to you." ☐

IN TIMES TO COME

Our October issue features a new novella, with a spectacular cover by David A. Hardy, by an old Analog favorite who hasn't appeared here nearly often enough of late: Poul Anderson. "Pele" is Anderson at his classic best, even though it's part of somebody else's future history. Set (with Niven's permission and blessing) against the background of Larry Niven's Man-Kzin Wars, it uses all of Anderson's special skills in world-building and storytelling in a sweeping tale of multi-layered conflicts with fully engaging characters both human and alien. What happens when scientific teams from two cultures with a long history of deep antagonism converge to observe the same ultra-dramatic astronomical event? Tensions naturally run high, and though both sides try to do the right thing, both interpret that concept by their own lights—which are as utterly and dangerously different as the evolutionary backgrounds from which they sprang.

Kyle Kirkland, Ph.D., returns with another science fact article, this time on stem cell research, one of the most active frontiers of biological research. Cells that can be induced to develop into whatever kinds of specialized cells the body might need are full of potential for radically new ways of restoring and maintaining health—and controversy over how those cells are obtained and used.

And, of course, we'll have a variety of other stories, quite likely including a tidbit or two for the season.

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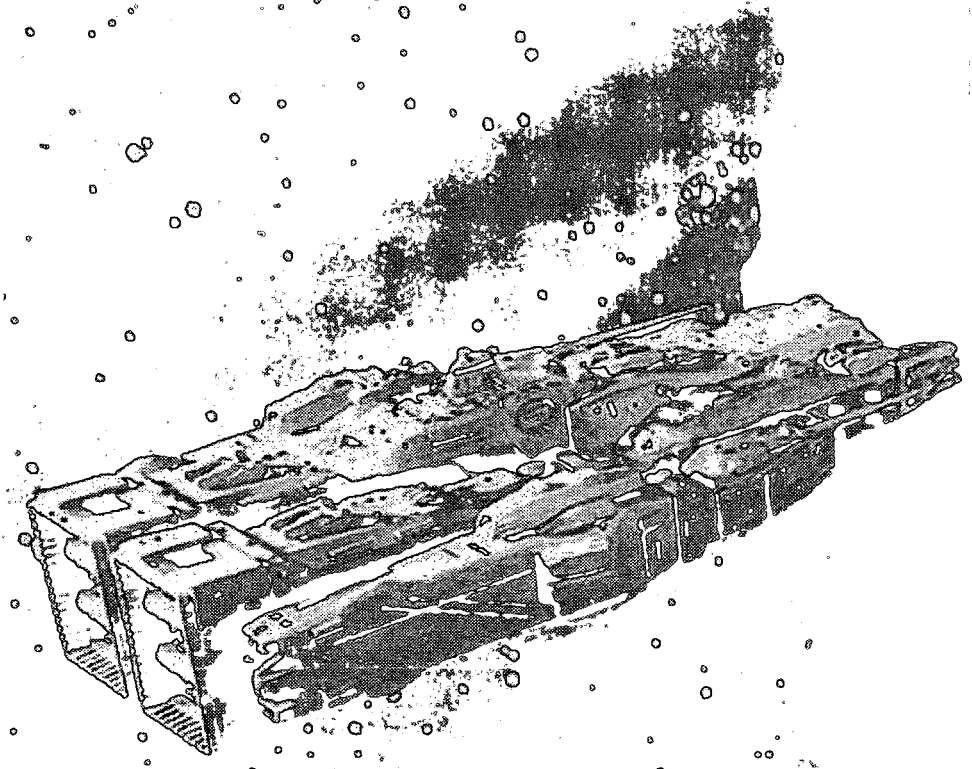
The Precipice, part IV of IV

Ben Bova



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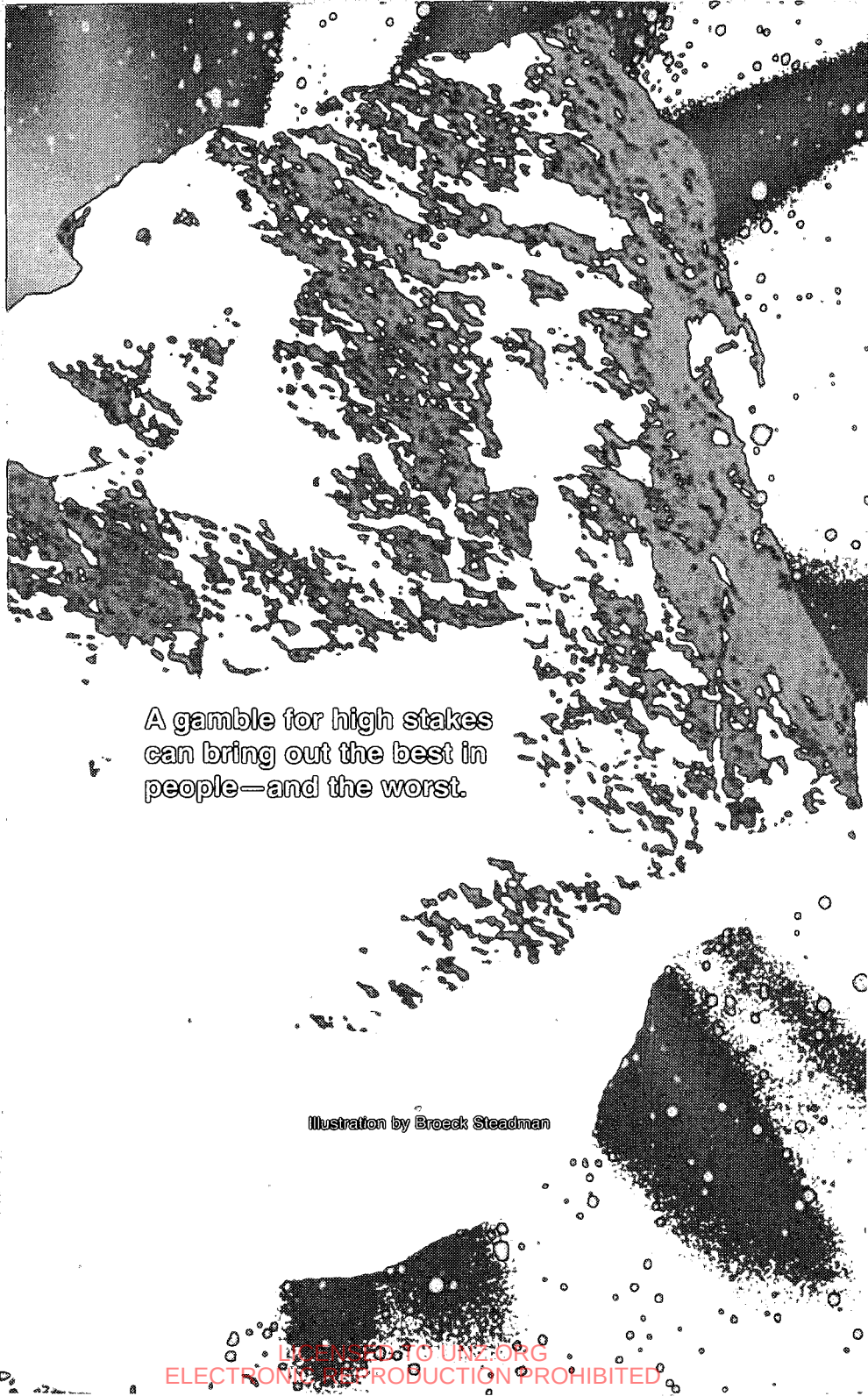

Illustration by Broeck Steadman

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Earth's climate has plunged over the Greenhouse Cliff. Sudden, disastrous warming has abruptly raised sea levels worldwide, flooded most coastal cities, and is turning croplands into deserts. Tens of millions are homeless; hundreds of millions face famine.

Dan Randolph, founder and CEO of Astro Manufacturing, Inc., wants to use the resources of the Asteroid Belt to help the battered, beleaguered people of Earth. But the costs of reaching the Belt, out beyond the orbit of Mars, doom his hopes to financial failure.

From his home in Selene, on the Moon, Martin Humphries sees Earth's catastrophe as an opportunity to gain wealth and power. He wants to acquire Dan Randolph's company, Astro Manufacturing, Inc. To lure Dan, Humphries offers to finance development of a fusion-powered space drive that will make it financially feasible—even profitable—to mine the rich resources of the Asteroid Belt. Devil-may-care pilot Pancho Lane is the sharpest astronaut on Astro's payroll. Humphries enlists her to spy on Randolph, who has assigned Pancho and the lusciously beautiful Amanda Cunningham to test-fly the first fusion-powered spacecraft. Pancho reluctantly agrees to spy for Humphries; she needs the money to support her sister, who is in cryonic suspension, waiting to be revived and cured of the cancer that led to her clinical death.

But Pancho finds she can't be disloyal to Dan Randolph. When she reveals to Dan that Humphries wants her to spy on him, Dan laughs and tells her to go right ahead. But he sends Pancho and Amanda to Selene.

To build the fusion drive, Dan turns to nanotechnology. Nobel laureate Kris Cardenas heads the nanotech lab at Selene. She is bitterly angry at the "nanoluddites" who have banned all nanotechnology from Earth, exiling her and anyone else who has used nanomachines in their bodies. Cardenas cannot return to Earth, and her children and grandchildren will not visit her on the Moon, for fear of being prevented from returning to Earth.

Meanwhile Pancho Lane sneaks into Martin Humphries' home while wearing a nanotech stealth suit that makes her invisible. The stealth suit was developed in Selene during the lunar community's brief and successful war of independence. It has been kept secret ever since. But Pancho "borrows" the "cloak of invisibility" and hacks into Humphries' files.

Humphries, meanwhile, has fallen desperately in love with Amanda Cunningham, so much so that he tries to keep her from flying the first test mission of Starpower 1, the fusion-driven spacecraft.

Dan Randolph intends to skip the test flights mandated by the International Astronautical Authority and send Starpower 1 directly to the Asteroid Belt—with himself aboard.

Humphries wants this first mission to fail. Once it does, Dan Randolph will be broken financially and his Astro Manufacturing Corp. available for sale on the cheap. Humphries enlists Kris Cardenas to sabotage Starpower 1 with nanomachines that will knock out the spacecraft's radiation shielding.

As Dan, Pancho, Amanda and planetary geologist Lars Fuchs reach the outer fringes of the Asteroid Belt, their ship's radiation shield begins to fail. Without the shielding they will be exposed to lethal radiation levels when a solar flare erupts.

STARPOWER 1

Sitting in her command chair on the bridge, Pancho asked, "How do we know the bugs ain't chewin' away at us now?"

Dan had never before seen Pancho look morose. Her long, lantern-jawed face was deadly serious now; her usual cocky grin had vanished.

"They were eating copper," Dan

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replied. "We got rid of the wire sample. The bugs went out the hatch with it."

"You hope."

"Fervently," said Dan.

"Well, the ship's wiring doesn't use any copper," Pancho said hopefully.

"It's all fiber optic. I know."

"There's plenty of copper here and there, though," Pancho went on. "Maybe only trace amounts, but if we got nanobugs eatin' copper, they could knock out half the microprocessors on board."

"That's great," Dan groused.

"The MHD channel!" she blurted. "It's got a superconducting magnet wrapped around it!"

"Holy Christ!"

"If that goes, the magnet'll dump all its energy—"

"It'll explode?"

"Like a frickin' bomb," Pancho said.

"Great. Just perfect," Dan muttered. "And there's not a double-damned thing we can do about it, is there?"

She shook her head. "Just hope it hasn't been infected."

Dan felt shaky inside. He had to swallow before he could speak. "Not much we can do if it has been."

"Could be worse," Pancho said, with false jollity. "If we had bugs that ate carbon, they'd be chewin' on us."

Dan saw no humor in that. "Where's Amanda?" he asked, pointing to the empty co-pilot's chair. "Shouldn't she be on duty up here?"

"She's back with Lars."

"In the sensor bay?"

"Yup. He's tryin' to jury-rig the electron microscope to get nanometer resolution."

"So he can see nanobugs?"

"If there're any to be seen, right."

"Those two seem to spend a lot of time together," Dan grumbled.

"Come to think of it, that's true."

Dan said nothing. He didn't like the idea of Amanda and Fuchs playing around together, but he had no evidence that they were. Fuchs seemed like a pretty stiff straight arrow. But you never know, Dan said to himself. Amanda certainly seems to enjoy being with him.

Pancho jabbed a finger toward one of the touchscreen displays. "Well, at least the magnetic shield's holdin' up OK. We're safe from radiation storms . . . for th' time being."

For the time being, Dan echoed silently.

"And the MHD channel?"

She tapped at a screen. "Normal as pie."

"The bugs haven't infected it, then."

"Maybe not."

"I think I'll go back to the sensor bay," Dan muttered. "See how those two are getting along."

"Gonna be their chaperon?" Pancho teased.

"Am I that obvious?"

"You sure are, boss. A real worry wart."

"Do you think they need a chaperon?"

"Prob'ly not. Mandy can take care of herself. Lars isn't like Humphries."

Nodding his agreement with Pancho's assessment of the situation, Dan said, "So I'll see how he's doing with the electron microscope."

"Good excuse," Pancho said, laughing.

Wishing he could forget his fears of the nanobugs, Dan left the bridge, poured himself a mug of coffee in the wardroom, and then headed along the passageway to the sensor bay. He could see them through the open hatch to the cramped little compartment, standing amid the humming instruments and flickering display screens, deep in earnest conversation.

My god, they look like Beauty and the Beast, Dan thought. Even in rumpled tan coveralls, with her shining blonde hair pinned up in a sensible, no-nonsense fashion, Amanda looked gorgeous. Her big blue eyes were totally focused on Fuchs. In his usual dead-black pullover and slacks, his barrel-chested thickset body made him look like a feral animal

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out of some wildlife vid: a boar or a black bear. But he wasn't growling or snarling at Amanda. Far from it.

"How's it going?" Dan asked as he stepped through the open hatch.

They looked startled, as if they hadn't seen him approaching.

Pointing to the gray tube of the miniaturized electron microscope, Dan forced a grin and asked, "Find any nanobugs?"

Fuchs turned away from Dan, toward the microscope. "No, it's hopeless. This machine will never resolve nanometer objects."

Dan wasn't surprised. "It wasn't designed to."

"I had thought perhaps I could boost its power," Fuchs went on, "but that was an idle hope."

"We've been reviewing the long-range sensor data," Amanda said, her cheeks slightly red. "Looking for a suitable asteroid, you know."

"And?"

Fuchs broke into a happy grin. It was so unusual that Dan was taken aback.

"We have an embarrassment of riches," he said, tapping at one of the touchscreens. "There are more than a dozen metal-rich bodies within a day's flight of us, or less."

Amanda said, "We've been trying to decide which one we should aim for."

Dan smiled at her. "That's easy. Go for the biggest one."

George held his breath as he edged closer to the corner of the big bedroom where Humphries and Dr. Cardenas sat. They both looked tense, although he seemed strung high with anticipation, while fear and anger glowered clearly on Cardenas' face.

George knew that they couldn't see him, yet he felt anxious, almost frightened, to be this close to them, invisible or not. Don't sneeze, he warned himself. Don't fookin' breathe.

"All right," Cardenas said tightly. "I'm listening."

Leaning slightly toward the sofa on which Cardenas sat, Humphries clasped his hands together and began, "Suppose I set you up in your own laboratory in some remote location on Earth. My father has holdings in Libya, for example. We could bring your grandchildren there, to be with you."

"And what would I be expected to do at this remote laboratory?" Cardenas asked. Her voice was without inflection, like an automaton's, her face a frozen mask.

"Nanomachines could be made to take carbon dioxide out of the atmosphere, can't they? Break the molecules down into carbon and oxygen atoms. The carbon could be buried, the oxygen released back into the air or sold as an industrial gas, whatever. That could stop the greenhouse warming in a year or two!"

Cardenas' expression did not change. "Nanotechnology is banned, you know that. No matter how you want to use it, you can't make nanomachines anywhere on Earth. You'd have the GEC, the world government, every religious nut on Earth going crazy if you even hinted that you're thinking of using nanotechnology."

Humphries smiled patiently. "We won't tell them, for god's sake. We just start doing it. In secret. Out in the Sahara or the middle of the ocean or Antarctica—anywhere. In a year or maybe even less, they'll start noticing the carbon dioxide levels going down. We can take out the other greenhouse gases, as well. They'll see that the greenhouse warming is lessening. *Then* we'll have them all by the balls! They'll have to accept what we're doing. They'll have no choice."

"And what happens if these nanomachines don't work exactly right? What happens if they start taking other carbon compounds apart? Like *you*, for instance. You're made of carbon atoms, aren't you?"

"That won't happen."

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"I know it won't happen," she said. "Because I won't do it. It's an absurd scheme."

"What's absurd about it?" Humphries demanded.

A slight, sardonic smile cracked Cardenas' facade. "You don't have any idea of how enormous Earth's atmosphere is. Do you know how many tons of carbon dioxide you'd have to remove? Billions! Tens of billions, at least! You'd have to cover Africa with nanomachines to remove that much carbon dioxide!"

"I'm sure that's an exaggeration," Humphries muttered, scowling.

Cardenas shot to her feet, startling George. "All right, you'd merely have to cover the Sahara desert. It's still beyond belief!"

"But—"

"And you'd never be able to keep it secret. Not a program of that scale."

"But it could be done, couldn't it?"

"It could be started," she admitted. "Until some fanatic drops a nuke on us. Or laces our drinking water with plague bacillus."

"I can protect you against terrorists," Humphries said.

Cardenas paced to the window, obviously thinking furiously. Turning back to Humphries, she said, "Using nanomachines on that scale is an invitation to disaster. Some fruitcake could steal a handful and reprogram them to take apart . . . plastics, for example. Or petroleum. Or use them as assassination weapons. You're talking about gobblers, for Christ's sake!"

"I know that," Humphries said coldly.

Cardenas shook her head. "It won't work. Aside from the sheer physical scale of the project, the authorities on Earth would never grant approval for using nanomachines. Never! And I can't say that I'd blame them."

Humphries slowly got to his feet. "You refuse to even try?"

"It's a hopeless task."

He sighed theatrically. "Well, I've tried to be reasonable. I thought we might be able to work something out."

"Let me go," Cardenas said, with a pleading note in her voice.

"I thought it would be a way for you to be with your grandchildren, as you want to be."

"Just let me go."

He gave her a sad look. "You know I can't do that. It's too great a risk for me."

"You can't keep me here forever!"

With a small shrug, Humphries asked, "What do you propose as a way out of this impasse?"

She stared at him, open-mouthed.

"I mean, you can see my problem. I know you can. How can I let you go when there's every chance that you'll tell people that I'm responsible for Dan Randolph's death?"

"But I'm responsible, too."

"Yes, I know. But you'd confess to it, wouldn't you?"

"I . . ." she hesitated, then said in a low, defeated voice, "I suppose I would, sooner or later."

"There you are," Humphries said softly. "The problem remains."

"You're going to have to kill me."

"I don't want to do that. I'm not a cold-blooded murderer. In fact, I'd like to see you reunited with your grandchildren, if it's at all possible. There must be some way we can work together, some way we can find around this problem."

"I don't see any," Cardenas whispered.

"Well, think it over," Humphries said, heading for the door. "I'm sure you can come up with a solution, if you just put your mind to it."

He smiled as he opened the door and left. George saw the guard standing out in the hallway before Humphries closed the door and its lock clicked shut.

As he strode down the hallway, Humphries mused to himself, It *could* work! If we could spread enough nanomachines, I could break the greenhouse warming in a couple of years. They'd be on their knees with gratitude.

He decided to put a small team of ex-

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perts together to study the possibilities dispassionately. Cardenas isn't the only nanotechnology guru in Selene, he assured himself.

BREAKOUT

Kris Cardenas stared at the locked door for several silent moments after Humphries left, then she suddenly broke into racking sobs. Face buried in her hands, body bent, she stumbled to the bed and threw herself onto it, crying inconsolably.

George stood uncertainly in the far corner of the bedroom, wondering what he should do. She's already hysterical, he said to himself. If I go and tap her on the shoulder and say, "Hi! I'm an invisible man!" she'll probably freak out altogether.

So he waited, fidgeting unhappily, until Cardenas stopped crying. It didn't take long. She sat up on the bed, took a deep breath, then got to her feet and went to the lavatory. When she came out again, it was obvious to George that she had washed her face and put on some makeup. But her eyes were still red, puffy.

Well, you can't stand here like a fookin' idiot forever, George told himself. Do something!

Before he could decide what to do, Cardenas walked to the window and pressed her fingers against the glass. Then she turned and seemed to survey the room. With a slight nod, she walked to the bare little desk and picked up its wooden, cushioned chair. It seemed heavy for her, but she carried it, tottering slightly, to the window.

She wants to crash the window and jump out of here, George realized. She'll just end up hurting herself.

He touched her arm lightly and whispered, "Excuse me."

Cardenas flinched and let the chair thump to the carpeting. She blinked, stared, saw nothing.

"Excuse me, Dr. Cardenas," George whispered.

She spun around in a complete circle, eyes wide.

"Who said that?"

George cleared his throat and replied, a little louder, "It's me, George Ambrose. I'm—"

"Where the hell are you?"

George felt slightly embarrassed. "I'm invisible."

"I'm going crazy," Cardenas muttered. She sank down onto the chair, right there in the middle of the room.

"No, you're not," George said, still keeping his voice low. "I'm a pal of Dan Randolph's. I'm here to get you out of this place."

"This is a trick."

"Is this room bugged? Do they have any cameras in here?"

"I . . . don't think so . . ."

"Look," George said, then immediately realized it was a foolish term to use. "I'm gonna take off me hood so you can see me face. Don't get scared now."

Cardenas looked more suspicious than frightened. George yanked the hood off his head and pulled off his face mask. It felt good to feel cool air on his skin.

She jumped out of the chair. "Christ almighty!"

"No, it's just me," he said, with a slight grin. "George Ambrose. I work for Dan Randolph, y'know."

Comprehension lit her eyes. "Walton's stealth suit! He didn't destroy it, after all."

"You know about it."

"Me, and four other people."

"There's a few more now," George said.

"How in the world did you ever—"

"No time for that now. We've got to get you out of here."

"How?"

George scratched at his beard. "Good question."

"You didn't bring along a suit for me, did you?" Cardenas asked.

"Should have, shouldn't I? We just din't think of it. We weren't certain

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where you were."

"So what do we do?"

George thought it over for a few moments. "They keep you in this room all the time?"

Cardenas nodded.

"Door's locked, isn't it?"

"Yes. And there's a guard outside . . . at least, every time they've brought a meal in to me, there's been a guard out in the hall. I imagine he's armed."

George's face lit up. "When do they bring you meals? When's the next one coming?"

Several hours later there was a single rap on the door, and then Cardenas heard the lock click. She glanced swiftly about the room but could no longer see George.

The door opened and the same silent, sour-faced woman in dark uniform came in, carrying a dinner tray. Cardenas could see a wiry young man standing on the other side of the doorway. The woman deposited the tray wordlessly on the coffee table in front of the sofa and then departed, silent and dour. The guard closed the door and locked it again.

Cardenas sat on the sofa. For the first time in days she had an appetite. She felt George's bulk settling on the cushions beside her.

"Smells good," George said.

She took the lid off a platter of fish fillets and vegetables.

"Looks good, too," George added.

"You're hungry," she said.

"Haven't eaten since breakfast."

"Help yourself."

George didn't wait to be coaxed. He lifted off his face mask again and dug in. Cardenas watched as fork and knife moved seemingly by themselves and chunks of dinner rose to his face, which seemed to be floating in midair. She found that if she looked hard enough, directly at him, she could see a faint flickering glitter, almost subliminal. Reflection of the ceiling lights scattered by the chips, she thought. But you have to know he's there to see it, and even then it's almost below the perception level.

"Don't you want any?" George asked.

"No, you go ahead."

"Eat the veggies, at least."

"I'll take the salad."

The meal was finished in a few minutes. George put his mask on again and completely disappeared.

"D'you tell 'em you're finished or do they send the maid back for the tray automatically?"

"I tell the guard. He sends for the maid."

"OK. Tell the guard you're finished and ask him to take the tray."

"He'll send for the maid."

"Tell 'im you don't want to wait for her. Make some excuse."

Cardenas nodded, got up from the sofa, and went to the door. She could sense George's body warmth as he padded along beside her.

She banged on the door with the flat of her hand. "I'm finished. Could you please take the tray?"

"I'll call the kitchen," came the guard's muffled voice.

"I can't wait! I've got to get to the toilet right away! I'm sick to my stomach. Please take the tray."

A moment's hesitation, then they heard the lock click. The door swung open and the guard stepped in, looking concerned.

"What's the matter? Something in the—"

The punch sounded like a melon hitting the pavement from a considerable height. The guard's head snapped back and his eyes rolled up. He crumpled to the floor. Cardenas saw his arms yanked up into the air and his body dragged into the room.

"Come on, now," George whispered to her.

They stepped out into the hallway. The door shut, seemingly by itself, and locked. She felt his hand engulf half her upper arm as George led her down the hallway to the stairs. The house seemed

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quiet at this hour, although a glance out the windows showed that the cavern outside was still lit in daytime mode.

The downstairs hall was empty, although Cardenas could hear the sounds of conversation floating through from somewhere. Neither of the voices sounded like Humphries' to her. They got to the foyer just inside the front door. Two young men in gray suits looked surprised to see her approaching them.

Frowning, the taller of the two said, "Dr. Cardenas, what are—"

George's punch spun him completely around. The other guard stared, frozen with surprise, until he was lifted off his feet by a blow to the midsection. Cardenas heard a bone-snapping *crunch!* and the guard fell limply to the tiled floor.

The front door jerked open and George hissed, "Come on, then!"

Cardenas ran out of the house, up the path that wound through the garden, and through the hatch that opened into Selene's bottommost corridor. She could hear George panting and puffing alongside her. Once they were through the hatch, George's hand on her arm brought her to a stop.

"I don't think anybody's followin' us," he said.

"How long do you think it will take for them to realize I'm gone?" she asked.

She sensed him shrugging. "Not fookin' long."

"What now, then?"

"Lemme get outta this suit," George muttered. "Hot enough inside here to cook a fella."

His face appeared, then his entire shaggy head. Within a minute he stood before her, sweating and grinning, a big red-haired mountain of a man in rumpled, stained olive green coveralls.

"That's better," George said, taking a deep breath. "Could hardly breathe inside that suit."

As they started walking swiftly along the corridor toward the escalator, Cardenas asked, "Where can I go? Where will I be safe? Humphries will turn Selene upside-down looking for me."

"We could go to Stavenger and ask him to take care of you."

She shook her head. "Don't put Doug in the middle of this. Besides, Humphries probably has his own people planted in Selene's staff."

"H'mm, yeah, maybe," George said as they reached the escalator. "Inside Astro, too, for that matter."

Suddenly frightened at the possibilities, Cardenas blurted, "Where can I go?"

George smiled. "I got the perfect hideout for ya. Long as you don't mind sharin' it with a corpsicle, that is."

BONANZA

"It's a beauty," Dan breathed, staring at the image on the control panel's radar screen.

"Purty ugly lookin' beauty," Pancho countered.

The radar image showed an elongated irregular lump of an asteroid, one end rounded and pitted, the other dented by what looked like the imprint of a giant mailed fist.

"It looks rather like a potato," said Amanda, "don't you think?"

"An iron potato," Dan said.

Fuchs came through the hatch and suddenly the bridge felt crowded to Dan. Lars isn't tall, he said to himself, but he fills up a room.

"That is it?" Fuchs asked, his eyes riveted to the screen.

"That's it," Pancho said, over her shoulder. She tapped at the keyboard on her left and a set of alphanumerics sprang up on the small screen above it. "Fourteenth asteroid discovered this year."

Amanda said, "Then its official name will be 41-014 Fuchs."

"How's it feel to have your name on an asteroid, Lars?" Pancho asked.

"Very fine," Fuchs said.

"You're the first person to have his name attached to a newly-discovered as-

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teroid in *years*," Amanda said. She seemed almost aglow, to Dan.

"Most of the new rocks have been found by the impact searchers," Pancho said. "Those li'l bitty probes don't get their names into the record."

"Asteroid 41-014 Fuchs," Amanda breathed.

He smiled and shrugged—squirmed, almost, as if embarrassed by her enthusiasm.

"The official name's one thing," Dan said. "I'm calling her Bonanza."

"Her?" Fuchs asked.

"Asteroids are feminine?" Pancho challenged.

Dan held his ground. "Hey, we speak of Mother Earth, don't we? And they call Venus our sister planet, don't they?"

"What about Mars?" Pancho retorted.

"Or Jupiter," said Amanda.

Pointing to the lump imaged on the radar screen, Dan insisted, "Bonanza's going to make us all rich. And very happy. She and her sisters are going to save the world. She's a female."

"Sure she's female," Pancho said laconically. "You want to dig into her, don't you?"

Fuchs sputtered and Amanda said, "Pancho, really!"

Dan put on an innocent air. "What a dirty mind you have, Pancho. I admire that in a woman."

Within three hours they were close enough to Bonanza to see it for themselves: a dark, deformed shape glinting sullenly in the wan light of the distant Sun. The asteroid blotted out the stars as it tumbled slowly end over end in the cold empty silence of space.

". . . eighteen hundred and forty-four meters along its long axis," Amanda was reading out the radar measurements. "Seven hundred and sixty-two meters at its maximum width."

"Nearly two kilometers long," Dan mused. He hadn't left the bridge at all during their approach to the metallic asteroid.

"Killing residual thrust," Pancho said, her attention focused on the control displays.

"Throttling down to zero," Amanda confirmed.

The asteroid slid out of view as the pilots established a parking orbit around it. Dan felt what little weight remained dwindle away to nothing. He floated up off the deck, stopped himself with a hand against the overhead.

He felt Fuchs come through the hatch behind him.

"Lars, we're going to be in zero *g* for a while," Dan said.

"I know. I think I'm getting accustomed to it."

"Good. Just don't make any sudden head movements and you'll be fine."

"Yes. Thank—*mein Gott!* There it is!"

The dark lopsided bulk of Bonanza rose in front of the bridge windows like some pitted, pockmarked monster, huge, overawing, menacing. Despite himself, Dan felt a wave of unease surge through him. It's like confronting an ogre, he thought, a giant beast from a fairy tale.

"Look at those striations!" Fuchs said, his voice vibrant with excitement. "This must have been broken off from a much larger body, perhaps a planetesimal from the early age of the solar system! We've got to get outside and take samples, drill cores!"

Dan broke into laughter. Fuchs turned toward him, looking confused. Even Pancho glanced over her shoulder.

"What so funny, boss?"

"Nothing," Dan said, trying to sober himself. "Nothing." Inwardly, though, he marvelled that the same sight that brought back to him memories of childhood dread stirred Fuchs into a frenzy of scientific curiosity.

"Come on," Fuchs said, ducking past the hatch. "We've got to suit up and go outside."

Dan nodded his agreement and followed the scientist. He's forgotten about zero-*g*, Dan realized. He's not worried

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about upchucking now, he's got too much work that he wants to do.

Amanda remained on the bridge as Pancho followed Dan down to the airlock.

"You're not thinkin' of goin' EVA, are you?" she asked Dan.

"I've been a qualified astronaut since before you were born, Pancho."

"You've been redlined. You can't go outside."

"And rain makes applesauce."

"I mean it, Dan," Pancho said, quite seriously. "Your immune system can't take another radiation dose."

"Fuchs can't go out there by himself," he countered.

"That's my job. I'll go with him."

"Nope. You stay here. I'll baby-sit him."

"I'm the captain of this craft," Pancho said firmly. "I can order you to stay inside."

He gave her a crooked grin. "And I'm the owner. I can fire you."

"Not till we get back to Selene."

Dan huffed out an impatient sigh. "Come on, Pancho, stop the chickenshit."

"Your medical records say—"

"Dammitall to hell and back, I don't care what the medical records say! I'm going out! I want to *see* this sucker! Touch her with my own hands."

"No gloves?"

They had reached the airlock, where the spacesuits hung in racks like suits of armor on display. Fuchs was sitting on the bench that ran in front of the racks, already into the lower half of his suit, sealing the boots to the cuffs of his leggings. Dan reached for the suit that bore his name stencilled on its chest.

"I thought you were scared of the radiation," Pancho said.

"I'll be OK inside the suit," Dan said. "The weather's calm out there; no radiation storm."

Fuchs looked up at them, said nothing.

"The regulations say—"

"The regulations say you're not supposed to bring pets aboard," Dan said, grinning again as he pulled the lower half of his suit from its rack and sat down beside Fuchs. "But I've got to look into my shoes every morning to make sure your damned snake isn't curled up inside one of them."

"Snake?" Fuchs yelped, looking alarmed.

Pancho planted her fists on her hips and glared down at Dan for a long moment. Then she visibly relaxed.

"OK, boss," she said at last. "I guess I can't blame you. But I'm gonna monitor your vitals back on the bridge. If I say come in, you come in. Right then. No arguments. Agreed?"

"Agreed," Dan replied instantly. A voice in his head was laughing mockingly. Are you satisfied? the voice asked. You've shown her that you're not a sick old man. Big deal. How are you going to feel when the cold clamps down on you and your bones start hurting again?

Doesn't matter, Dan answered himself. I'm not going to stay cooped up in here like a cripple. To hell with it; I don't really give a damn. If I've got to die, I'd rather wear out than rust out. What difference does it make?

"Clear for EVA." Amanda's voice came through the speaker in Dan's helmet.

He was in the airlock, sealed in his suit, feeling like a robot in a metal womb.

"Opening outer hatch," he said, pressing a gloved finger on the red light of the control panel.

"Copy, outer hatch."

The hatch slid open and Dan felt his pulse start to quicken. How long has it been since I've been outside? he asked himself. That sardonic voice in his head answered, Not since you got the radiation overdose, jiggering commsats in the Van Allen Belt.

Ten years, Dan realized. That's a long time to be away from all this.

He pushed himself through the hatch

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and floated in emptiness. The Universe hung all around him: stars solemn and unwinking, staring at him even through the heavy tinting of his fishbowl helmet. Turning slowly, he saw the Sun, strangely small and pale, with its arms of faint zodiacal light outstretched on either side of it.

Freedom. He knew he was confined inside the spacesuit and he couldn't survive for a minute without it. Yet, hanging there weightlessly in the silent emptiness of infinity, Dan felt free of all the world, alone with the cosmos, in tune with the ethereal music of the spheres. Glorious freedom. Radiation be damned, he felt he could soar out into the universe forever and leave the petty lusts and hates of humankind far behind. It wouldn't be a bad way to die.

Then the asteroid slid into his view. Massive, ponderous, an enormous, pitted, dark, looming reality hanging over him like an ominous cloud, a mountain floating free in space. *Starpower 1* looked pitifully small and helpless alongside the two-kilometer-long asteroid; like a minnow next to a whale. Dan suddenly understood how Jonah must have felt.

You can't scare me, he said to the asteroid. You're two kilometers of high-grade iron ore, pal. You're going to look beautiful to a lot of people on Earth. Money in the bank, that's what you are. Jobs and hope for millions of people. Bonanza: that's your name and that's just what you are.

"Ready for EVA." Fuchs' voice broke into Dan's silent monologue.

"Clear for EVA, Lars," he heard Amanda reply.

Dan squeezed the right handgrip on his maneuvering controls with the lightest of touches. The cold gas jet on the backpack squirted noiselessly and he turned enough to be looking back at the ship. *Starpower 1* glinted nicely in the starlight. She still looked brand-new, shining, not a pit or a scratch on her. The airlock hatch slid open and a spacesuited figure stood framed in it.

"Exiting the airlock," Fuchs said, his voice trembling slightly.

"Come on, Lars," Dan called. "Isn't she a beauty?"

Fuchs jetted toward him. Dan saw that his suit was bristling with hammers and drills and all sorts of equipment.

"It's enormous!" He sounded awestruck.

"She's just an average-sized chunk of metal," Dan said. "And as soon as you chip a piece off her, we can claim her."

Fuchs showed no hesitation at all, although he seemed a bit clumsy working the controls of his maneuvering thrusters. For a moment Dan thought he was going to ram into the asteroid, but at the last instant Fuchs fired a braking blast and hovered a scant few meters above its pitted, pebbly surface.

Dan jetted toward him, then, with a bare touch of the handgrip controls, lowered himself to the surface of the asteroid. He felt his boots make contact and then recoil slightly away. Not much gravity, he thought, as he puffed down again and finally stood on the surface of Bonanza. Clouds of dust rose where his boots made contact with the surface; they just hung there, barely moving in the minuscule gravity.

It took Fuchs three tries to get firmly onto the surface; he kept coming down too hard and bouncing off. In the end, Dan had to reach out and yank him down.

"Don't try to walk," he told Fuchs. "The gravity's so light you'll float up and away."

"Then how—"

"Slide your boots along." Dan demonstrated a couple of steps, shuffling up even more dust. "Like you're dancing."

"I don't dance very well," Fuchs said.

"This isn't the smoothest dance floor in the solar system, either."

The asteroid's surface was rough and uneven, covered with a powdery coating of dust, much like the surface of the Moon. Dan thought it was more like standing on the deck of a boat, though,

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than on solid ground. There wasn't really a horizon; the rock just *ended*. Pinhole craters peppered the surface, pebbles and fist-sized rocks littered it, and out along its far end, Dan could see a more sizeable crater, a big depression with a raised rim all around it.

"How much iron do you think we've got here?" Dan asked.

"We'll have a good measure of its mass by the time we return to the ship," Fuchs said. "With the ship orbiting the asteroid, we have a classic two-body system. It's simple Newtonian physics."

Dan thought to himself, He's a scientist, all right. Ask him a simple question and you get a dissertation. Without the answer to your question.

"Lars," he said patiently, "can't you give me some idea of this lump's mass?"

Fuchs spread his hands. In the spacesuit, he looked like a bubble-topped fireplug with arms.

"A back-of-the-envelope guesstimate?" Dan coaxed.

"Oh . . . considering its dimensions . . . nickel-iron asteroids are typically no more than ten percent nickel . . . it must be somewhere in the neighborhood of seven or eight billion tons of iron and eighty million tons or so of nickel."

Dan's eyes went wide. "That's five or six times the world's steel production in its best year! Before the floods and all!"

"There are impurities, of course," Fuchs warned. "Platinum, gold and silver, other heavy metals."

"Impurities, right," Dan agreed, cackling. His mind was spinning. One asteroid is enough to supply the world's steel industry for years and years! And there are thousands of these chunks out here! It's all true! Everything I hoped for, all those wild promises I made—they're all going to come true!

Fuchs seemed oblivious to it all. "I want to look at those striations," he said, turning toward the far end of the asteroid. His effort made him rise off the surface and Dan had to yank him down again.

"Take a sample here, first," Dan said. "Then we can claim it."

The light was so dim that Dan could see Fuchs' head outlined inside his bubble helmet. He nodded and slowly, very slowly, got down into a kneeling position. Then he pulled a rock hammer from his equipment belt and chipped off a bit of the asteroid. The effort raised more dust and lifted him off the surface again, but this time he clawed at the ground with one gloved hand and pulled himself back down.

"Anchor yourself, Lars," Dan said. "Hammer a piton in and tether it to your belt."

"Yes, of course," Fuchs answered, fumbling with the equipment clipped to his waist.

Dan said, "Record this, Amanda, and mark the time. Starpower Ltd. has begun taking samples of asteroid 41-014 Fuchs. Under the terms of the International Astronautical Authority protocol of 2021, Starpower Ltd. claims exclusive use of the resources of this asteroid."

"I've got it," Amanda's voice replied. "Your statement is being beamed to IAA headquarters on Earth."

"Good," Dan said, satisfied. He recalled from his school days the story of the Spanish explorer Balboa, when he first saw the Pacific Ocean. From what he remembered of the tale, Balboa waded out into the surf and claimed the whole bloody ocean and all the lands bordering on it for Spain. They thought big in those days, Dan said to himself. No pissant IAA to worry about.

Fuchs got the knack of shuffling along the surface of the asteroid and spent nearly two hours happily chipping out samples and making stereo videos. Dan worried about the dust they were kicking up. It could get into the joints of our suits, he thought. Damned stuff just hangs there; must take a year for it to settle back again.

He saw a bulge off to his right, like a small knoll or a rounded hill. That must be the tail end of this rock, Dan told

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himself. Looking back at Fuchs, he saw that the scientist had finally anchored himself to the ground and was busily chipping away, raising lingering clouds of dust.

"I'm going to go up to that ridge," he told Fuchs, pointing, "and see what's on the other side."

"Very well," said Fuchs, still bent over his sampling.

Dan shuffled carefully along, worrying about the dust. On the Moon, dust raised from the ground was electrostatically charged; it clung stubbornly to the suits and helmet visors. Probably the same thing here.

He started up the slight rise. Something didn't feel right. Suddenly his boots slid out from under him and he tumbled, in dreamlike slow motion, face forward. His fall was so gentle that he could put out his hands and stop himself, but he bounced off the dusty ground and found himself floating *up* the rise like a hot-air balloon gliding up the side of a mountain.

Dan's old astronaut training took over his reflexes. In his mind he saw clearly what was happening. The gravity on this double-damned rock is so low that I'm floating off it! He saw the bulbous end of the asteroid sliding slowly beneath him and, beyond it, the star-strewn infinity of space.

Twisting his body so that he pointed himself back toward the asteroid's bulk, Dan squirted his maneuvering jets and lurched back to the asteroid. Gently, tenderly, he touched down again on its surface. Fuchs was still tapping away with his sampling hammer, rising off the ground with every blow, his anchored tether pulling him back again for another crack.

Dan was breathing hard, but otherwise no worse the wear for his little excursion. With even greater care than before, he shuffled back to stand beside Fuchs and help bag the samples he'd chipped out.

At last Pancho said sternly, "Time to come in, guys."

"Just one more sample," Fuchs replied.

"*Now*," Pancho commanded.

"Aye-aye, cap'n," said Dan. He rapped his gloved knuckles on Fuchs' helmet. "Come on, Lars. You've done enough for one day. This rock isn't going to go away; you can come back another time."

Amanda was at the airlock to help them take off their backpacks and dust-spattered spacesuits. Dan caught a strange, pungent smell once he removed his helmet. Not like the sharp firecracker odor of the lunar dust; this was something new, different.

Before he had time to puzzle out the dust's odor, Pancho came down to the airlock area, looking so somber that Dan asked her what was the matter.

While Fuchs chattered happily with Amanda, Pancho said, "Bad news, boss. Another section of the superconductor is heating up. If it goes critical it could blow out the whole magnetic shield."

Dan felt his jaw drop open. Without the shield, they'd be cooked by the next solar radiation storm.

"We've gotta get back to Selene pronto," Pancho said. "Before another flare breaks out."

"What're our chances?" Dan asked, his throat dry.

She waggled a hand. "Fifty-fifty . . . if we're lucky."

TEMPO 9

"We won't have to go outside, will we?" Cardenas asked nervously.

She was following George through the maze of pumps and generators up on the topmost level of Selene. Color-coded pipes and electrical conduits lined the ceiling; Cardenas wondered how anyone could keep track of which was which. The air hummed with the subdued sounds of electrical equipment and hydraulic machinery. On the other side of that ceiling, she knew, was the grassy expanse of the Grand Plaza—or the bare dusty regolith of the Moon's air-

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less surface.

"Outside?" George echoed. "Naw, there's a shaft connectin' the tempo to the tunnel . . . if I can find th' fookin' tunn—ah, there it is!"

He pulled a small hatch open and stepped over its coaming, then reached a hand back to help Cardenas. The tunnel was dark, lit only by the hand torch George carried. Cardenas expected to see the evil red eyes of rats in the darkness, or hear the slithering of roaches. Nothing. Selene is clean of vermin, she thought. Even the farmlands have to be pollinated artificially because there aren't any insects here.

Not yet, she thought. Sooner or later, though. Once we start allowing larger numbers of people up here, they'll bring their filth and their pests with them.

"Here we are," George said.

In the circle of light cast by his torch, she saw the metal rungs of a ladder leading up along the wall of the tunnel.

"How much farther does the tunnel go?" she asked, in a whisper, even though she knew there was no one else there.

"Another klick or so," George answered. "Yamagata people wanted to drill all the way through the ringwall and out to *Mare Nubium*. Got too expensive. The cable car over the top was cheaper."

He scampered up the ladder, light and lithe despite his size. Cardenas started to follow him.

"Wait a bit," George called down to her. "Got to get this hatch unstuck."

She heard metal groan. Then George said, "OK, up with you, now."

The ladder ended in an enclosed area about the size of her apartment unit, down inside Selene. It was a cylindrical shape, like a spacecraft module.

"We're on the surface?" Cardenas asked, trying to keep her voice from shaking.

"Buried under a meter of dirt from the regolith," George said happily. "Safe as in church."

"But we're outside."

"On the slope of the ringwall. Just below the cable line. The original idea was, if there's an emergency with the cable trolley, people could stay in here till help arrives."

She looked around the shelter warily. A pair of double-decker bunks stood at the far end, the hatch of an airlock at the other. In-between was a small galley with a freezer, microwave oven and sink; some other equipment she didn't recognize; two padded chairs; a desk with a computer atop it and a smaller chair in front of it . . .

And a big metal cylinder sitting in the middle of the floor, crowding the already-cramped quarters. One end of the cylinder was attached to a large pair of tanks and a miniaturized cryostat.

"Is that a dewar?" Cardenas asked.

George nodded. "Had to hide the woman inside it from Humphries."

"She's dead?"

"Preserved cryonically," George said. "There's hopes of reviving her."

"She won't be much company."

"'Fraid not. But I'll pop back here every few days, see that you're OK."

Stepping toward the desk, trying to hide her anxiety, Cardenas asked, "How long will I have to stay here?"

"Dunno. I'll have a chat with Dan, see what we should do."

"Call Doug Stavenger," she said. "He'll protect me."

"I thought you didn't want to put him in the middle of this scrape."

She wrapped her arms around herself, trembling with cold fear. "That's before I knew you were going to put me out here."

"Hey, this isn't so bad," George said, trying to sound reassuring. "I useta live in tempos like this for months at a time."

"You did?"

"Yup. Me and my mates. This is like home-sweet-home to me."

She looked around the place again. It seemed smaller than her first view of it.

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Closing in on her. Nothing between her and the deadly vacuum outside except the thin metal of the shelter's cylinder and a heaping of dirt over it. And a corpse in the middle of the floor, taking up most of the room.

"Call Stavenger," she pleaded. "I don't want to stay here any longer than I have to."

"Sure," said George. "Lemme talk to Dan first."

"Make it quick."

"The magnetic shield is going to blow up?" Dan asked, for the thirtieth time.

Pancho sat across the table from him in *Starpower 1*'s wardroom. Amanda was on the bridge as the ship raced at top acceleration back toward Selene. Fuchs was in the sensor bay, assaying the samples he'd chipped from Bonanza.

"You know how superconductors work," Pancho said, grimly. "They have to stay cooled down below their critical temperature. If they go above that temperature, all the energy in the coil gets dumped into the hot spot."

"It'll explode," Dan muttered.

"Like a bomb. Lots of energy in the superconductor, boss. It's a dangerous situation."

"There's more than one hot spot?"

"Four of 'em, so far. Wouldn't be surprised if more of 'em crop up. Whoever bugged this ship didn't want us to get back home."

Dan drummed his fingers on the table top. "I can't believe Kris Cardenas would do this to me."

"It's Humphries, pure and simple," said Pancho. "He could kill you with a smile, any day."

"But he'd need Kris to do this."

"Look," Pancho said, hunching forward in her chair. "Doesn't matter who spit in whose eye. We got troubles and we've gotta figger out how to save our necks before that magnetic coil goes up like a bomb."

Dan had never seen her look so earnest. "OK, right. What do you recommend?"

"We shut down the magnetic field."

"Shut it down? But then we'd have no radiation shield."

"Don't need it unless there's a flare, and we can prob'ly get back to Selene before the Sun burps another one out."

"Probably," Dan growled.

"That's the chance we take. I like those odds better'n letting the coil's hot spots build up to an explosion that'd rupture the ship's skin."

"Yeah, you're right," Dan said, reluctantly.

"OK, then." Pancho got up from the table. "I'm gonna shut it down now."

"Wait a minute," said Dan, reaching for her wrist. "What about the MHD channel?"

Pancho shrugged. "No problems so far. Prob'ly hasn't been bugged."

"If it goes, we're dead, right?"

"Well . . ." She drew the word out. "We *could* dump the coil's energy in a controlled shutdown. That wouldn't affect the thrusters."

"But we'd lose our electrical power."

"We could run on the fuel cells and batteries—for a while."

"Long enough?"

Pancho laughed and headed for the hatch. "Long as they last, boss," she said over her shoulder.

"Murphy's Law," Dan growled after her.

If anything can go wrong, it will: that was Murphy's Law. Now I can add Randolph's corollary to it, he thought: If you turn off your radiation shield, you're certain to be hit by a solar flare.

MESSAGES

George shooed everyone out of the mission control center, except for the chief who insisted hotly that the center must have at least one human controller on duty at all times.

If she'd been a man, George would have simply picked him up and heaved him through the door out into the corridor. Instead, the chief on this shift was a

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rail-thin, pasty-faced, lank-haired woman with the personality of an Arkansas mule. She would not leave the center.

Restraining the urge to lift her off her feet and carry her out to the corridor, George pleaded, "I've got send a private message to Dan Randolph. I can't have anybody listenin' in on it."

"And why not?" she demanded, hands on hips, narrow nostrils flaring angrily.

"None of your fookin' business," George snarled. "That's why not."

For long moments they glared at each other, George towering over her, but the woman totally unfazed by him.

"It's Dan's own orders," George said at last, stretching the truth a little. "This is ultra-sensitive stuff."

The woman seemed to think that over for a second, then said more reasonably, "You take the console over there, on the end. I'll set you up with a private channel. Nobody else in here but you and me, and I won't eavesdrop. OK?"

George started to say no, but realized that this was the best he could accomplish, short of physical mayhem.

Before he could agree, though, Frank Blyleven pushed through the double doors, his normally smiling face wrinkled into a puzzled frown.

"What's going on here?" the security chief demanded, walking up the aisle between the consoles. "I got a report that you're throwing controllers out of the center."

Heaving an impatient sigh, George explained all over again that he had to get a message through to Dan. "In private," he said. "Nobody listenin' in."

Blyleven crossed his arms over his chest and tried to look authoritative. It didn't work. To George he looked like a red-faced shopping mall Santa in mufti.

"Very well," he said. "Send your message. I'll sit by the corridor door and make certain nobody disturbs you."

Surprised, George thanked him and headed for the console that the chief controller had indicated. Blyleven went to the last row of consoles and sat down at the one closest to the door. Surreptitiously, he tapped the keyboard a few times. When George finished his message and erased it from the comm system's memory core, Blyleven had a copy that he could pawn to Humphries.

Dan felt nervous as he watched Pancho and Amanda shut down the radiation shield. Dumping all that electromagnetic energy didn't bother him; it was the idea that now they had no protection against another solar storm except the thin hull of the ship itself.

". . . shutdown complete," Pancho announced. "Magnetic field zeroed out."

"Zero field," Amanda confirmed.

"Naked to mine enemies," Dan murmured.

"How's that, boss?" Pancho asked, looking up over her shoulder toward him.

"I feel naked," Dan said.

"Don't worry. Sun looks calm enough, for the time being. Even if it shoots out a flare, we can always get into our suits and go for a swim in one of the fuel tanks."

"That wouldn't be very helpful," Amanda pointed out, not realizing that Pancho was joking. "The high-energy protons would set off all sorts of secondary particles from the fuel's atoms."

Pancho frowned at her. Amanda looked from her to Dan and then back to her control panel.

"I think I'll go back and see how Lars is doing," she said, getting up from her chair.

"Have fun," Pancho said.

Dan watched her step through the hatch, then slid into her vacated chair.

"Don't look so glum, boss. We're battin' along at one-third g with no sweat. Be back in lunar orbit in less'n four days."

"I had wanted to stop to sample those other two rocks," Dan said.

"Can't take the chance. Better to—hold one. Incoming message from Selene. George Ambrose."

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"I'll take it here," said Dan. "By the way, have you told mission control that we've shut down the shield?"

"Not yet, but they'll see it on the telemetering. It's recorded automatically."

Dan nodded as George's bushy red-maned face appeared on the screen. Quickly, in a worried whisper, George explained how he'd located Cardenas and spirited her off to the temporary shelter.

"She wants t'see Stavenger," George concluded. "I told her I'd talk to you first. She'll be perfectly OK in the tempo for a coupla weeks, if we need to keep her stashed there. So . . . what d'you want me to do, Dan?"

George's image on the screen froze. Dan could see that he must have been at the mission control center when he'd sent the message. Good. He must've cleared out the place to make sure nobody could eavesdrop.

Now I've got to send him a reply that just about anybody can listen to, Dan thought. This is going to be like an old-time Mafioso speaking into a tapped telephone.

"George, I think she's right. Do as she asks . . . as carefully as you can. She's important to us; there's a lot she and I have to talk about when I get back. We've got some problems here on the ship and we're heading back home. If all goes well, we should be back in lunar orbit in less than four days. I'll keep you informed, and you let me know how things are going there."

Dan reviewed his own message, decided there was nothing he needed to add to it, then touched the SEND button on the comm panel.

He started to get up from the copilot's seat when the comm unit pinged.

"'Nuther message comin' in," Pancho said needlessly.

A young man's face appeared on the screen. He looked annoyed. "General notice to all spacecraft and surface vehicles. A class 4 solar flare has been observed by the early-warning sensors in Mercury orbit. Preliminary calculations of the interplanetary field indicate the resulting radiation storm has a ninety percent chance of reaching the Earth-Moon system within the next twelve hours. All spacecraft in cislunar space are advised to return to the nearest safe docking facility. All activities on the lunar surface will be suspended in six hours. Anyone on the surface is advised to seek shelter within six hours."

Dan sagged back into the chair.

Pancho tried to smile. "You called it, boss: Murphy's Law."

STORM SHELTER

Four worried people clustered around the table in *Starpower 1*'s wardroom. The wallscreen showed a chart of the solar system with the radiation cloud that the solar flare had belched out appearing as a shapeless gray blob twisted by the interplanetary magnetic field. It was approaching Earth and its Moon rapidly. Deep in the Asteroid Belt a single pulsating red dot showed where their ship was.

Dan said to the computer, "Show the projections for the next two days."

The cloud grew and thinned, but surged out past the orbit of Mars and then engulfed the inner Belt and overran the blinking red dot that marked *Starpower 1*'s position.

Pancho made a sound halfway between a sigh and a snort. "No way around it. We're gonna get hosed."

Amanda looked up from her palmcomp. "If we could pump all our remaining fuel into one tank, it could serve as a shelter . . . of sorts."

"I thought the secondaries would get us," Dan muttered.

"They'd be high," Amanda admitted, "but if we could pressurize the fuel it might absorb most of the secondary particles before they reached us."

"If we're plumb in the middle of the tank," Pancho said.

"Yes. Inside our suits, of course."

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"Can the suits handle the temperature? We're talking about liquid hydrogen and helium; damned close to absolute zero."

"The suits are insulated well enough," Pancho said. Then she added, "But nobody's ever tried a dunk in liquid hydrogen with 'em."

"And we'd have to be dunked for god knows how many hours," Dan muttered.

Fuchs had not said a word. His head was bent over his own palmcomp.

"How much protection would the fuel give us?" Dan asked glumly.

Amanda hesitated, looked down at her handheld screen, then said, "We'd all need hospitalization. We'd have to set the flight controls to put us into lunar orbit on automatic."

"We'd all be that sick?" Pancho asked.

Amanda nodded solemnly.

And I'd be dead, Dan thought. I can't take another radiation dose like that. It would kill me.

Aloud, he tried to sound reasonably hopeful. "Well, it's better than sitting here with our thumbs jammed. Pancho, start transferring the fuel."

"How high can we pressurize one of the tanks?" Amanda wondered.

"I'll check the specs," said Pancho. "Come on, we've got to—"

"Wait," Fuchs said, looking up at them. "There is a better way."

Dan looked hard at him. Fuchs' eyes were set so deeply that it was difficult to see any expression in them. Certainly he was not smiling. His thin slash of a mouth looked tight, hard.

"Computer," Fuchs called, "display position of asteroid 32-114."

A yellow dot began blinking near the inner edge of the Belt.

"That's where we must go," Fuchs said flatly.

"It's half a day off our course home," Pancho objected.

"Why there, Lars?" Amanda asked.

"We can use it for a storm shelter."

Dan shook his head. "Once the cloud runs over us, the radiation is isotropic. It comes from all directions. You can't hide behind a rock from it."

"Not behind the rock," Fuchs said, with growing excitement. "Inside it!"

"Inside the asteroid?"

"Yes! We burrow into it. The body of the asteroid will shield us from the radiation!"

"That would be great," Dan said, "if we had some deep drilling equipment aboard and a few days to dig. We don't have either."

"We don't need them!"

"The hell we don't," Dan shot back. "You think we're going to tunnel into that rock with your little core sampler?"

"No, no, no," Fuchs said. "You don't understand. That rock is a chondritic asteroid!"

"So what?" Pancho snapped.

"It's porous! It isn't a rock, not like Bonanza. It's an aggregate of chondrites—little stones, held together by gravity."

"How do you know that?" Dan demanded. "We haven't gotten close enough to—"

"Look at the data!" Fuchs urged, waving a thick-fingered hand at the wallscreen.

"What data?" The screen still showed the chart with the radiation cloud.

Fuchs pointed his palmcomp at the screen like a pistol and the wall display suddenly showed a long table of alphanumerics.

"Look at the data for its density," Fuchs said urgently. He jumped up from his chair and bounded to the screen. "Look! Its density isn't much more than that of water! It *can't* be a solid object! Not with such a density. It's porous! An aggregation of stones! Like a . . ." he searched for a word, ". . . like a pile of rubble . . . a beanbag chair!"

Dan stared at the numbers, then looked back at Fuchs. The man was clearly excited now.

"You're sure of this?" he asked.

"The numbers don't lie," Fuchs said. "They can't."

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Pancho gave out a soft whistle. "Shore wish we had somethin' more'n numbers to go on."

"But we do!" Fuchs said. "Mathilde in the Main Belt, and Eugenia—several c-class bodies among the Near-Earth Asteroids—they are all aggregates, not solid at all. Microprobes have examined them, even gone inside them!"

"Porous," Dan muttered.

"Yes!"

"We can dig into them without drilling equipment?"

"They are probably highly tunnelled, naturally."

Dan stroked his chin, trying to think, trying to decide. If he's right, it'd be better than dunking ourselves in a pool of liquid hydrogen for hours on end. If Fuchs is right. If we can burrow into the asteroid and use it for a storm shelter. If he's wrong, we're all dead.

Pancho spoke up. "I say we go for the asteroid, boss."

Dan looked into her steady light brown eyes. Is she saying this because she knows I won't make it otherwise? Is she willing to take the chance with her own life because it's the only chance we've got to save mine?

"I agree," Amanda said. "The asteroid is the better choice."

He turned back to Fuchs. "Lars, are you absolutely certain of all this?"

"Absolutely," Fuchs replied, without an instant's hesitation.

"OK," Dan said, feeling uneasy about it. "Change course for—which one is it?"

"Asteroid 32-114," Fuchs and Amanda answered in unison.

"Point and shoot," Dan said.

Dan tried to sleep while *Starpower 1* raced to the chondritic asteroid, but his dreams were troubled with faces and visions from the past and a vague, looming sense of dread. He awoke feeling more tired than when he'd crawled into his bunk.

He felt stiff and sore, as if every muscle in his body were strained. Tension, he told himself. But that sardonic voice in his mind retorted, Age. You're getting to be an old man.

He nodded to his image in the lav mirror. If I live through this I'm going to start rejuve therapy.

Then he realized what he'd said: *If* I live through this.

He put on a fresh set of coveralls and grabbed a mug of coffee on his way to the bridge. Amanda was in the command chair, with Fuchs sitting at her right.

"Pancho's sleeping," Amanda said before Dan could ask. "We'll be making rendezvous with 114 in . . ." she glanced at one of the screens, ". . . seventy-three minutes. I'll wake her in half an hour."

"Can we see the rock yet?" Dan asked, peering into the black emptiness beyond the windows.

"Telescopic view," said Amanda, touching a viewscreen.

A lumpy, roundish shape appeared on the screen. To Dan it looked like a partially-deflated beach ball, dark gray, almost black.

"We're getting excellent data on it," Fuchs said. "Mass and density are confirmed."

"It's porous, as you thought?"

"Yes, it has to be."

"It's certainly no beauty," Amanda said.

"I don't know about that," replied Dan. "It looks pretty good to me. In fact, I think I'll call it Haven."

"Haven," she echoed.

Dan nodded. "Our haven from the storm." Silently he added, If those numbers for its density mean what Fuchs says they do.

SELENE

The worst part of being alone in the temporary shelter was the waiting. There was nothing to do in the tempo except pace its length—an even dozen strides for Kris Cardenas—or watch the commercial video broadcasts that the

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shelter's antenna pulled in from the relay satellites.

Maddening. And there was the high-tech sarcophagus in the middle of the floor with its frozen woman inside its gleaming stainless steel cylinder. Not much company.

When the hatch in the floor suddenly squeaked open, Cardenas jumped with surprise so hard she nearly banged her head on the shelter's curving roof. For an instant she didn't care who was coming through the hatch; even an assassin would be a welcome relief from the boredom of the past night and day.

But she puffed out a big sigh of relief when she saw George Ambrose's brick-red mane rising through the open hatch. George climbed through and grinned at her.

"Dan says I should take you to Stavenger."

Cardenas nodded. "Yes. Fine."

Doug Stavenger was not happy to see her. He sat behind his desk and eyed her with raw disappointment showing in his expression. Cardenas sat in the cushioned chair before the desk like an accused criminal being interrogated. George stood by the office door, beefy arms folded across his chest.

"You seeded Randolph's ship with gobblers?" he said, his voice hollow with shocked disbelief.

"Specifically tailored to take apart copper compounds," Cardenas admitted, feeling shaky inside. "Nothing more."

"Isn't that enough?"

"It was meant to cripple the ship's radiation shield," she said defensively. "Once they found out about it, they'd abort their mission and return here."

"But they didn't find out about it until they were deep in the Belt," Stavenger said.

George added, "And now they're sailing into a fookin' radiation storm without a shield."

"This could become a murder," Stavenger said. "Four murders."

Cardenas bit her lip and nodded.

"And Humphries was behind this scheme," Stavenger said. It was a statement, not a question.

"He wanted Randolph's mission to fail."

"Why?"

"Ask him."

"He's a major investor in the project. Why would he want it to fail?"

"Ask him," she repeated.

"I intend to," said Stavenger. "He's already on his way here."

As if on cue, Stavenger's phone chimed. "Mr. Humphries here to see you," said the phone's synthesized voice.

"Send him in," Stavenger said, touching the stud on the rim of his desk that opened the door.

George stood aside, clearly glowering through his beard, as Humphries walked in. Humphries looked at Cardenas, half turned in her chair, then at Stavenger. With a slight shrug he took the other chair in front of the desk.

"What's this all about?" he asked casually as he sat down. "What's going on?"

"It's about attempted murder," Stavenger said.

"Murder?"

"Four people are caught in a solar storm out in the Belt without a working radiation shield."

"Dan Randolph, you mean." Humphries almost smiled. "That's just like him, barging ahead like a bull in a china shop."

Stavenger bristled. "You didn't get Dr. Cardenas here to seed Randolph's ship with gobblers?"

"Gobblers?"

"Nanomachines. Disassemblers."

Humphries glanced at Cardenas, then said to Stavenger, "I asked Dr. Cardenas if there was any way that Randolph's ship could be . . . er, disabled slightly. Just enough to get him to turn back and abort his flight to the Belt."

Cardenas started to reply, but Stavenger said heatedly, "If they die—if

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any one of them dies, I'll have you arraigned for premeditated murder."

Humphries actually smiled at Stavenger. "That's so far-fetched it's ludicrous."

"Is it?"

"I had Randolph's ship sabotaged so he would abort his flight and come back to Selene. I admit to that. Any sane man would have turned around and headed for home as soon as he found the sabotage. But not Randolph! He pushed on anyway, knowing that his radiation shield was damaged. That's his decision, not mine. If there's a crime in this, it's Randolph committing suicide and taking his crew with him."

Stavenger barely held on to his composure. His fists clenched, he asked through gritted teeth, "And just why did you want to sabotage his ship?"

"So the stock in Astro Corporation would drop, why else? It was a business decision."

"Business."

"Yes, business. I want Astro; the lower its stock, the easier for me to buy it up. Dr. Cardenas here wanted her grandchildren. I offered to get her together with them in exchange for a pinch of nanomachines."

"Gobblers," Stavenger said.

"They weren't programmed to harm anyone," Cardenas protested. "They were specifically set to attack the copper compound of the superconductor, nothing more."

"My father was killed by gobblers," Stavenger said, his voice as cold and sharp as an icepick. "Murdered."

"That's ancient history," Humphries scoffed. "Please don't bring your family baggage into this."

Visibly restraining himself, Stavenger stared at Humphries for a long, silent moment. Electricity crackled through the office. George decided that if Stavenger came around the desk and started beating up on Humphries, he would keep the door closed and prevent anyone from coming to the bastard's aid.

At last Stavenger seemed to win his inner struggle. He took a shuddering breath, then said in a low, seething voice, "I'm turning this matter over to Selene's legal department. Neither of you will be allowed to leave Selene until their investigation is finished."

"You're going to put us on trial?" Cardenas asked.

"If it were up to me," Stavenger said, "I'd put the two of you into leaky spacesuits and drive you out into the middle of *Mare Nubium* and leave you there."

Humphries laughed. "I'm glad you're not a judge. And, by the way, Selene has no capital punishment, does it?"

"Not yet," Stavenger growled. "But if we get a few more people like you here, we'll probably change our laws on that point."

Humphries got to his feet. "You can threaten all you like, but I don't think your courts will take this as personally as you are."

With that, he strode to the door. George stepped aside and let him open it for himself. He noticed that there was a thin sheen of perspiration on Humphries' upper lip as he left the office.

The instant the door closed again, Cardenas broke into sobs. Half doubled over in her chair, she buried her face in her hands.

Stavenger's icy composure melted. "Kris . . . how could you do it? How could you let him . . ." He stopped and shook his head.

Without looking up at him, Cardenas said in a tear-choked voice, "I was angry, Doug. Angrier than you can know. Angrier than I myself knew."

"Angry? At Randolph?"

"No. At *them*. The crazies who let this greenhouse cliff ruin the world. The fanatics who've exiled us, who won't let me come to Earth to see my children, my grandchildren. And they won't come here, not even for a visit. I wanted to punish them, get even with them."

"By killing Randolph?"

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"Dan's trying to help them," she said, looking up at him at last, her face streaked with tears. "I don't *want* them helped! They made this mess. They shut me out of their lives. Let them stew in their own juices! They deserve whatever they get."

Stavenger shook his head, bewildered. He handed Cardenas a tissue and she dabbed at her reddened eyes.

"I'm going to recommend that you be placed under house arrest, Kris. You'll be able to go anywhere in Selene except the nanotech lab."

She nodded wordlessly.

"And Humphries?" George asked, still standing by the door.

"Same thing, I suppose. But he's right, the smug slimebag. We don't have capital punishment, we don't even have a jail here in Selene."

"House arrest for him would be a lark," George said.

Stavenger looked disgusted. But then his chin came up and his eyes brightened. "Unless we take it out on his wallet."

"Huh?"

With a slow smile spreading across his youthful face, Stavenger said, "If he's found guilty of murder, or even attempted murder, maybe the court can divest him of his share of Starpower and keep him from taking over Astro Corporation."

George huffed. "I'd rather punch his ribs in."

"So would I," Stavenger admitted. "But I think he'd *rather* have his ribs punched in than to have to give up Astro and Starpower."

HAVEN

"There it is," Pancho sang out. "How's that for navigation?"

Dan crouched slightly behind the command chair and peered through the window. The asteroid was visible to their naked eyes now, against the distant glow of the Sun's zodiacal light, a dumbbell-shaped dark mass tumbling slowly end over end.

Fuchs stood beside Dan, his hands on the back of Amanda's chair.

"It's two bodies in contact," he said. "Like Castallia and several others."

"Looks like a peanut," said Dan.

"A peanut made of rock," Pancho said.

"No, no," Fuchs corrected, "a peanut made up of thousands of little stones, chondrules, that are barely holding together in their very weak mutual gravitational attraction."

"Uh-huh."

"Look, you can see craters on the surface."

Dan strained his eyes. How in hell can he see craters on that black slug in this dim lighting?

"They have no rims," Fuchs went on, talking fast in his excitement. "Smaller objects have collided with the asteroid but they don't make impact craters as they would on a solid body. They simply burrow into the loose rubble."

"Same as we're gonna do," Pancho said.

"Our storm cellar," Amanda added, glancing up at Fuchs.

It's our storm cellar only if he's right, Dan added silently. If that chunk out there really is a beanbag and we can dig into it until the storm's over.

Aloud, he asked, "How long before the radiation starts to build up?"

"Four hours, plus a few minutes," Pancho said. "Plenty time."

You hope, Dan said to himself.

She established *Starpower 1* in a orbit close around the tumbling asteroid and then the four of them floated weightlessly down to the airlock, where Dan and Fuchs had already assembled six emergency tanks of air. As they wriggled into their spacesuits, Fuchs begged to go out the airlock first, but Dan overruled him.

"Pancho goes first, Lars. You're still a tenderfoot out there."

Through his fishbowl helmet, Fuchs' broad face frowned in puzzlement. "But

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my feet are fine," he said. "Why are you worried about my feet?"

Dan and Pancho both laughed, but Amanda shot an annoyed glance at Dan and said, "It's an American expression, Lars. From their western frontier, long ago."

"Yep," Dan conceded. "I learned it from Wild Bill Hickok."

Getting serious, Pancho said, "We can go together, Lars and me—whenever you guys are ready to stop horsin' around."

"Aye-aye, cap'n," said Dan, touching his helmet with a gloved hand in a sloppy salute.

Pancho and Fuchs went through the airlock and, once it cycled, Dan and Amanda. While he stood in the cramped metal chamber, listening to the air pump's clatter dwindle to silence, he heard Fuchs' excited voice through his helmet speaker:

"It's like a sand pile!"

Dan offered a swift thanks to whatever gods there be. Maybe we'll all live through this, after all.

With Amanda, he went through the airlock and then jetted the hundred meters or so separating the ship from the asteroid. It sure looks solid, Dan thought, staring at the black, slowly tumbling mass as he approached it. And yes, there were craters here and there with no rims to them; just holes, as if some giant had poked his fingers into the asteroid.

Then he saw Fuchs' helmet and shoulders; the rest of him was in some sort of a pit. He's digging like a kid in a sandbox, Dan saw.

As he got closer, Dan saw that the surface of the asteroid looked hazy, blurred. Is he stirring up that much dust? Dan asked himself. No, it's not just where Fuchs is digging. It's everywhere. The whole surface of the asteroid is blurry. What the hell is causing that?

"Are my eyes going bad or is the surface blurred?" he said into his helmet microphone.

"Dust," came Fuchs' immediate reply. "Particles from the solar wind give the dust an electrostatic charge. It makes the dust levitate."

"That doesn't happen on the Moon," Dan objected.

"The Moon is a very large body," said Fuchs. "This asteroid's gravity is too weak to hold the dust on the surface."

Just then Dan touched down on Haven. It was like stepping on talcum powder. His boots sank into the dark dust almost up to his ankles even though he came down with a feather light touch. Cripes, he thought, it's like one of those black sand beaches in Tahiti.

Dan turned and saw Pancho, long and lean even in her spacesuit, gliding across the asteroid's dusty surface toward him.

"Bring out the air tanks, Mandy," Pancho said.

Amanda soared weightlessly to *Starpower 1*'s airlock, then emerged again towing a string of six tall gray cylinders behind her. In her gleaming white spacesuit she looked like a robot nurse followed by a half-dozen unfinished pods.

"Better start diggin', boss," Pancho said.

Dan nodded, then realized that she might not be able to see the gesture. There wasn't all that much light out here, and they had decided to keep their helmet lamps off to save their suit batteries.

"We go with the buddy system," Dan said as he unlimbered the makeshift shovel he had carried with him. "You and me, Pancho. Amanda, you stay with Lars."

"Yes, of course," Amanda replied.

It wasn't quite like digging at the beach. More like working on a giant, black hunk of Swiss cheese, Dan thought. There were holes in the surface, tunnels that had apparently been drilled by stray chunks of rock hitting the asteroid. There was no bedrock, just a loose rubble of black rounded grains,

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the largest of them about the size of a small pebble. It's a wonder they hold together, Dan thought.

"Here's a ready-made tunnel for two," Pancho called to him. He saw her slowly disappearing into one of the tunnels.

It was wide enough for the two of them, just barely.

"How far down does it go?" Dan asked as he gingerly slid over the lip of the crater, careful not to catch his backpack.

"Dunno," Pancho answered. "Deep enough to ride out the storm. Better start fillin' in the hole."

He nodded inside his helmet and took a tighter grip on his improvised shovel: it had been a panel covering an electronics console. They had to cover themselves with at least a meter of dirt to protect against the oncoming radiation.

As he dug away at the sides of the sloping tunnel, Dan expected the gritty dirt to slide down into their hole. That's what would have happened on Earth, or even on the Moon. But Haven's gravity was so slight that the tunnel walls would not cave in no matter how furiously he dug into them.

In short order he and Pancho, working side by side, had buried themselves as deep as their waists. Not enough, Dan knew. Nowhere near enough, not yet.

"How're we doing . . . on time?" he asked Pancho, panting from the exertion of digging.

She straightened up. "Lemme see," she said, tapping at the keyboard on her left forearm. Dan could see a multi-colored display light up on her bubble helmet.

"Radiation level's not up much over ambient yet," she said.

"How soon?" Dan asked impatiently.

The lights on her helmet's inner face flickered, changed. "Hour and a half, maybe a little less."

Dan went back to digging, blinking sweat out of his eyes, wishing he could wipe his face or just scratch his nose. But that was impossible inside the suit. Should have worn a sweat band, he told himself. Always did when I went outside. Been so long since I've done any EVA work I forgot it. Hindsight's always perfect.

"Y'know we're gonna need at least a meter of this dirt over us," Pancho said, digging alongside him.

"Yep."

"And then dig our way out, after the cloud passes."

"Yep," Dan repeated. It was the most he could say without stopping work. His muscles ached from the unaccustomed exertion.

It seemed like hours later when he heard Pancho's voice in his helmet speaker. "How're you guys doin', Mandy?"

"We're fine. We found a lovely cave and we have it almost completely filled in."

"Once you're all covered over it's gonna degrade our radio link," Pancho said.

"Yes, I'm sure it will."

"Got your air tanks in there with you?"

"Yes, of course."

Dan saw that their air tanks were still lying out on the surface, more than arm's reach away.

"OK, keep your radio open. If we get completely cut off, you stay in the hole for fourteen hours. Got that?"

"Fourteen hours, check."

"Time count starts now."

"Fourteen hours from now," Amanda confirmed.

"Have a nice day."

"We'll see you in fourteen hours," Fuchs said.

"Right," said Dan, silently adding, Dead or alive.

To Pancho, he said, "I'd better drag the air tanks in here." Before she could object he pushed himself out of the hole and soared up above the dark, uneven ground. Dan glanced around but could not find the shelter that Amanda and

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Fuchs had dug for themselves. They did a good job, he thought as he tapped his jet thruster controls to push himself back to the surface.

The cylinders weighed next to nothing, but still he was careful with them as he slid them down into the pit. They still have mass, and inertia, Dan knew. I could break open Pancho's helmet or spring her suit's joints if I let one of these things bang into her.

By the time he wormed himself back into the pit beside her, Dan was bathed in cold sweat and puffing hard.

"You're not used to real work, are you, boss?" Pancho teased.

Dan shook his head inside his helmet. "Soon as we get back to Selene, I'm going in for rejuvenation therapy."

"Me too."

"You? At your age?"

"Sooner's better'n later, they claim."

Dan humphed. "Better late than never."

"Radiation level's startin' to climb," Pancho said, starting to paw at the sides of their pit again. "We better get ourselves buried or neither one of us'll get any younger."

"Or older," Dan muttered.

Buried alive. This is like something out of an Edgar Allan Poe story, Dan said to himself. He knew Pancho was mere centimeters from him; so were the air tanks. But he could see nothing. They were buried under nearly a full meter of loose rubble, curled fetally, nothing to see or hear or do except wait.

". . . are you doing?" He heard Amanda's voice, scratchy and weak, through his helmet's speaker.

"We're OK," Pancho said. "I've been thinkin' we oughta organize a square dance."

Dan suppressed a groan. That's just we need, he thought, redneck humor. Then, surprisingly, he laughed. He hadn't heard the term "redneck" since he'd been in Texas, long ages ago. There are no rednecks off-Earth, Dan realized. You don't get sunburned out here. Cooked, maybe. Fried by radiation. But not tanned, not unless you sit under the sunlamps in the gym at Selene.

He wiggled his right hand through the loose rubble encasing him and felt for the keyboard on his left forearm. By touch he called up the ship's sensor display. They had programmed the suits to show the displays on the inner surfaces of their bubble helmets. Nothing but streaks of colored hash. Either the pile of dirt atop them or the radiation storm was interfering with their link to the ship. Probably a combination of both, he thought.

"What's the time?" Dan asked.

At least he could talk with Pancho. Even if the radio link broke down completely they were close enough to scrunch through the dirt and touch helmets so that they could talk through sound conduction.

"More'n thirteen hours to go, boss."

"You mean we've been down here for less than an hour?"

"Forty-nine minutes, to be exact."

"Shit," Dan said, with feeling.

"Take a nap. Best way to spend the time."

Dan nodded inside his helmet. "Nothing else to do."

He heard Pancho giggle softly.

"What's funny?"

"Mandy and Lars. I bet they're tryin' to figger out how to get the two of them into one suit."

Dan laughed, too. "Maybe you and I ought to try that."

"Boss!" Pancho cried in mock shock. "That's sexual harassment!"

"Nothing else to do," he repeated. "I can't even jerk off inside this double-damned suit."

"I can," Pancho teased.

"Now *that's* sexual harassment," Dan grumbled.

"Nope. Just better design."

Dan licked his lips. He felt thirsty, chilled, yet he was sweating. His stomach was queasy.

"How do you feel, Pancho?"

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"Bored. Tired. Too jumpy to sleep. How 'bout you?"

"The same, I guess. Every part of me aches."

"How's your blood pressure?"

"How in hell would I know?"

"You hear your pulse in your ears?"

"No."

"Then you're OK, I guess."

"Thank you, Dr. Pancho."

"Go to sleep, boss. That's what I'm gonna try to do."

"I thought you said you were too jumpy."

"Yeah, but I'm gonna give it a try. Close my eyes and think pleasant thoughts."

"Good luck."

"You try it, too."

"Sure."

Dan closed his eyes, but his thoughts were far from pleasant. Opening them again, he fumbled with his wrist keyboard until he got the suit's radiation sensor displayed on his helmet. The graph was distorted by the curve of his helmet, and blurry. He tried to focus his eyes on it. Looks OK, he said to himself. Curve's going up, but the slope is low and it's a far distance from the red zone.

Try to sleep. He was certainly tired enough for it. Relax! Think about what you're going to do when you get back to Selene. I'd like to personally punch out Humphries' lights. Dan pictured Humphries' surprise when he broke his nose with a good straight right.

Somewhere in his mind an old adage sounded: Revenge is a dish best taken cold.

Punching in Humphries' face would be fun, but what would *really* hurt the bastard? He's tried to kill me. He may succeed yet; we're not out of this. If I die he'll move in and take over Astro. How can I prevent him from doing that? How can I stop him, even from the grave?

Dan chuckled bitterly to himself. I'm already in my grave, he realized. I'm already buried.

* * *

NANOTECHNOLOGY LABORATORY

Charley Engles looked worried, upset. He nervously brushed his sandy hair back away from his forehead as he said, "Kris, I'm not supposed to let you in here."

It was well past midnight. Cardenas was surprised that anyone was still working in the lab complex. Selene's security people hadn't bothered to change the entry code on the main door; she had just tapped it out and the door had obligingly slid open. But Engles had been working in his cubicle, and as soon as he saw Cardenas striding determinedly past the empty work stations toward her own office, he popped out of his cubbyhole and stopped her.

"We got notified by security," he said, looking shamefaced. "You're not allowed in here until further notice."

"I know, Charley," she said. "I just want to clear out my desk."

Charles Engles was a young grad student from New York whose parents had sent him to Selene after he'd been crippled in a car crash. Even knowing that he could never return to them once he'd taken nanotherapy, his parents wanted their son's legs repaired so he could walk again.

"The cameras . . ." Engles pointed to the tiny unwinking red lights in the corners of the ceiling. "Security will send somebody here once they see you."

"It's all right," she said, trying to mask her inner tension. "I'll only be here a few minutes. You can go back to your work."

Instead, he walked with her as she headed for her office.

"What's this all about, Kris? Why do they want to lock you out of your own lab?"

"It's a long story and I'd rather not go into it right now, Charley. Please, I just need a few minutes in my office."

He looked unhappy, almost wounded. "If there's anything I can do to help . . ."

Cardenas smiled and felt tears welling

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in her eyes. "That's very kind of you, Charley. Thanks."

"I mean, I wouldn't be able to walk if it weren't for you."

She nodded and added silently, And now that you can walk you'll never be allowed to return to Earth.

"Well . . ." he shifted uneasily from one foot to the other. "If there's anything you need, anything at all, just let me know."

"Thanks, Charley. I'll do that."

He stood there for another awkward moment while Cardenas wondered how long it would take Security to send someone to apprehend her. Finally he headed back to his own cubicle, reluctantly. She walked slowly toward her office.

Once he stepped into his cubicle, though, Cardenas swiftly turned down a side passageway toward the rear of the laboratory complex. She passed a sign that proclaimed in red letters AUTHORIZED PERSONNEL ONLY BEYOND THIS POINT. This was the area where newly-developed nanomachines were tested. The passageway here was lined with sealed, airtight chambers, rather than the cubicles out front. The door to each chamber was locked. The passageway itself was lined with ultraviolet lamps along its ceiling. Each nanomachine type was designed to stop functioning when exposed to high-intensity ultraviolet light; a safety precaution.

Cardenas passed three doors, stopped at the fourth. She tapped out its entry code and the steel door opened inward a crack. She slipped into the darkened chamber and leaned her weight against the heavy door, closing it. With a long, shuddering sigh, she reset the entry code from the panel on the wall, effectively locking the door to anyone who might try to get in. They'll have to break the door down, she told herself, and that will take them some time.

By the time they get the door open, I'll be dead.

* * *

Dan dreamed of Earth, a confused, troubled dream. He was sailing a racing yacht, running before the wind neck and neck with many other boats. Warm tropical sun beat down on his shoulders and back as he gripped the tiller with one hand while the boat's computer adjusted the sails for every change in the breeze.

The boat knifed through the water but suddenly it was a car that Dan was driving at breakneck speed through murderously heavy traffic. Dan didn't know where he was; some city freeway, a dozen lanes clogged with cars and buses and enormous semi rigs chuffing smoke and fumes into the dirty gray, sullen sky. Something was wrong with the car's air-conditioning; it was getting uncomfortably hot in the driver's seat. Dan started to open his window but realized that the windows had to stay shut. There's no air to breath out there. He said to himself, knowing it was ridiculous because he wasn't in space he was on Earth and he was suffocating, choking, coughing.

He woke up coughing with Pancho's voice blaring in his ears, "Recharge your backpack, boss! You're runnin' low on air."

Blackness. He couldn't see a thing. For a moment he felt panic surging through him, then it fell into place. Buried in the asteroid. Time to refill his backpack's air tank. In the dark. By touch.

"Lemme help you," Pancho said.

Dan sensed her beside him. The gravelly dirt shifted, crunched, Something bumped into his side.

"Oops. 'Scuse me."

Dan pushed one hand through the gritty stuff, remembering where he'd put the cylinders.

"I've got the hose," he said.

"OK, good. That's what I was lookin' for."

"Groping for, you mean."

"Whatever. Hand it to me now."

Dan felt her hand pushing against his

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side. "I can do it," he said.

"Better let me," said Pancho. "You're tired and fatigue makes you sloppy, causes mistakes."

"I'm all right."

"Sure. But just lemme do it, huh? Tired astronauts don't live long."

"And rain makes applesauce," he mumbled, pushing the end of the hose into her waiting hand.

"Don't open it up yet," Pancho warned. "Don't want grit or dust contaminating the air."

"I know," he groused.

It seemed to take hours. Dan tried to keep from coughing but the air in his suit seemed awfully thick; his chest was hurting. He pictured old pantomime comedy routines as he and Pancho haltingly fumbled with the air hose, working blindly, and refilled each other's suit tanks. They filled Dan's backpack first, and within a minute the could take a deep breath again without it catching in his throat.

Once they filled Pancho's backpack he heard her inhale deeply. "Best canned air in the solar system," she announced happily.

"What time is it? How long do we have to go?"

"Lemme see . . . seven and a half hours."

"That's how long we've been down here?"

"Nope, that's how long we still have to go," Pancho answered.

"Another seven and a half hours?"

Pancho laughed. "You sound like a kid in the back seat of a car."

He huffed, then broke into a chastened grin. "I guess I was whining, wasn't I?"

"A little."

A new thought struck Dan. "After the time's up, how do we tell if the radiation's really gone down enough for us to get back to the ship?"

"Been thinkin' about that. I'll worm my extensible antenna wire up to the top of this rubble heap and see if we can link with the ship. Then it'll be purty simple to read the ship's sensors."

"Suppose the ship's comm system's been knocked out by the radiation."

"Not likely."

"But what if?"

Pancho sighed. "Then I'll just hafta stick my head out and see what my suit sensors read."

"Like an old cowboy video," Dan said. "Stick your head out and see if anybody shoots at you."

"Hey, boss, you really did learn a lot from Wild Bill Hickok, didn't ya?"

This late at night, there was only one man on duty monitoring Selene's security camera network. He was a portly, balding former London bobby who had spent his life's savings to bring himself and his wife to the Moon and live in comfortable, low-gravity retirement. He'd found retirement so boring, however, that he pleaded with Selene's personnel department to allow him to work, at least part-time.

The uniform they gave him wasn't much; just a set of glorified coveralls with an insignia patch on the left shoulder and his name badge clipped over its breast pocket. But at least he could spend three nights each week sitting alone and content, watching the videos his wife always complained about while still feeling that he was doing something worthwhile. He half-dozed, leaning back in his padded swivel chair, as the twenty display screens arranged in a semicircle around his desk flashed views from Selene's hundreds of security cameras. Actually, only nineteen of the screens showed the cameras' scenes; the screen directly in front of the desk was showing the football match from Vancouver, live. But with the sound well muted, of course.

The computer did all the real work. The toffs in the main office programmed the computer with a long list of things that would be considered questionable or downright illegal. If the computer de-

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tected any such activity it sounded an alarm and indicated where and what was going on.

With score still tied and only four minutes left in the final period, the blasted computer buzzed.

The guard frowned with annoyance. His central screen winked out for an instant, then displayed a ceiling-eye view of a woman walking through one of the labs. UNAUTHORIZED PERSON blinked in red across the bottom of the screen.

It took a few minutes to coax the information out of the computer, but finally the guard phoned the security chief, waking him of course, with the news that Dr. Kris Cardenas had entered the nanotechnology laboratory. The chief grumbled and cast a bleary eye at the guard, but at least had the good grace to say, "Thanks. I'll send somebody down there."

Then he hung up and the guard went back to watching the football game. It was going into overtime.

HAVEN

Try as he might, Dan could not get back to sleep. Pancho had attempted to call Amanda and Fuchs, but there was no response from them.

"Must be a lotta sizzle outside," she said.

Dan thought she sounded worried. Not her usual sassy self. Or maybe she's just tired. Or bored.

How can anybody be bored with this storm only a meter over our heads? Dan asked himself. Some storm. No thunder and lightning. No noise at all, unless you count the crackle and hiss when you try to use the radio.

Quiet. Deadly quiet.

Dan found the water nipple in his suit's collar and took a sip. Flat and warm. Like recycled piss.

More than seven hours to go. I'll be bonkers by then: stark, raving nutty.

Then he tasted blood in his mouth.

It was like an electric shock. His entire body flinched. Everything else disappeared from his mind.

Bleeding gums, he thought, trying to fight down the terror rising in him. One of the prime symptoms of radiation sickness.

Or maybe you accidentally bit your tongue, he told himself.

Yeah, sure, answered that sardonic voice in his head. You've had a bout of radiation sickness before, you know the drill. Only this time there's no place to go to, nothing to do except sit here in this grave and let the radiation do its job on you.

"Pancho," he croaked, surprised at how dry his throat was.

"Right here, boss."

"Can you turn on your suit's recorder?"

"Yeah, I think so . . ."

Dan sensed her fumbling in the dirt. This must be the way moles live, he thought, depending on touch instead of sight. His stomach was fluttering, nauseous. Christ, don't let me toss my cookies inside the double-damned helmet, he begged silently.

Pancho said, "Testing, one, two, three." A moment later he heard the words repeated.

"OK, the recorder's workin'."

"Good," said Dan. "Get this down." He cleared his throat. It felt raw, raspy. Then, in as normal a voice as he could produce, he pronounced:

"I am Dan Randolph, CEO of Astro Manufacturing Corporation. This is my last will and testament. The recording equipment will automatically mark this statement with the date and time."

"That's right," Pancho said.

"Don't interrupt, kid. Where was I? Oh, right, last will and testament. I hereby bequeath all my stock in Astro Corporation to my friend and loyal employee, Priscilla Lane, together—"

Pancho was so shocked she didn't even bristle at the use of her proper name. "To me? Are you loco?"

"Don't interrupt!" Dan snapped. "All my Astro stock to Priscilla Lane, togeth-

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er with all my personal belongings and possessions." He had to stop and take a few breaths. Then, "And I nominate Priscilla Lane to take my place on the board of directors of Astro Corporation."

He thought about it for a few moments, then nodded, satisfied. "OK, that's it. You can turn off the recorder now."

"What'd you do that for? Howcome you—"

"I'm not going to make it, kid," Dan said, tiredly. "The radiation's getting to me. I want you to take my place on the board of directors and fight that sumbitch Humphries with every gram of strength you've got."

"Me? I'm just a hick engineer . . . a rocket jock, for cryin' out loud."

"You're my heir, Pancho. Like a daughter. I don't have any family to leave anything to, and besides, you know Astro as well as anyone does."

"Not the board of directors."

Dan laughed weakly. "You'll roll right over them, kid. The board needs some fresh, young blood. You'll have to fight Humphries, of course. He'll want to be made chairman once I'm gone."

In a quieter voice, Pancho asked, "You're talkin' like you're at death's door."

"I think I am. My gums are bleeding. I feel woozy. My ears are ringing. I just hope I don't get the shits."

"The storm's almost over," she said.

"So am I."

"Once we get back into the ship we can zip back to Selene in a couple of days. Maybe faster! I can goose her up to maybe half a *g*."

"And how will you brake her? Impact? Dive right into Alphonsus?"

Pancho fell silent for several moments. Dan was glad she couldn't see him. The way his insides felt, his hands would probably be shaking like a palsied old man's if they weren't buried in the asteroid's rubble.

"They can cure radiation sickness back at Selene," Pancho said at last. "Use nanomachines."

"If I make it back to Selene."

"Only about seven hours to go," she said. "Radiation's levelin' off."

"Not as deep as a well," Dan quoted, "or as wide as a church door, but it's enough. It'll do."

"You goin' delirious?"

"No, that's just Shakespeare. 'Romeo and Juliet.'"

"Oh. Yeah, right."

"I'm going to take a nap, kid. I feel pretty tired."

"Good idea, I guess."

"Wake me when it's over."

Kris Cardenas was surprised at how her hands trembled as she worked. Programming nanomachines to disassemble carbon-based molecules was a snap, a no-brainer. Just a slight modification to the procedure they used every day to build diamond mechanisms out of bins of soot.

It wasn't the difficulty of the work. As she sat at the lab bench, peering intently at the desktop screen that displayed what the atomic force microscope was showing, she thought about the consequences.

Gobblers. I'm deliberately creating a batch of gobblers. If they get loose . . .

Calm down! she scolded herself. Go through this logically, step by step.

OK, they'll break in and find me dead. Lying on the floor. I'll leave a note on the computer screen. Put it in big red letters, so they can't miss it. I'm only making a microsample of gobblers and I'm disabling their assembly capabilities. They can't reproduce. They'll be contained inside my body.

But what if they get outside your body? They'll be taking you apart from the inside. What's to stop them from getting out?

Nothing, she told herself. So I'll turn on the UV overheads before I swallow the bugs. That will destroy them once they get outside my body.

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A knock on the door startled her.

"Dr. Cardenas? We know you're in there. Open up, please."

She wiped the display from the AFM and began hurriedly typing her suicide note.

"Warning. I have ingested a microgram of nanomachine disassemblers. They are programmed to take apart carbon-based molecules. Do not allow them to go beyond the confines of this laboratory. Disinfect the lab with high-intensity ultraviolet light before moving my body or touching anything in this room. Notify—"

Someone banged on the door, hard. "Kris! It's Doug Stavenger. You don't have to do this. Come on out."

She scanned the red block letters on the display screen and erased the final word; no need to notify Doug, he's already here.

"Kris, it's not your fault." Stavenger's voice was muffled by the heavy steel door, but she heard the urgency in it well enough. "Come out and talk this over with me."

She got off the spindly-legged stool and went to the sampling site at the end of the bench. A gleaming cup of lunar aluminum sat there, half full of water that contained the nanomachines that were going to kill her.

"Kris," Stavenger called, "you've spent your life developing nanotechnology. Don't throw it all away. Don't give them another reason to say nanomachines are killers."

She picked up the cup and held it in both hands, thinking, I can't live with this guilt. I've committed murder. I've killed four people.

Stavenger was shouting through the locked door, "That's what they'll say. You know that. They'll say that nanomachines killed the foremost researcher in the field. They'll use it to show how dangerous nanomachines are, how right they've been all along to ban them."

She looked from the cup to the closed, locked door. It was Humphries' idea, but I did it. Willingly. He pulled my strings and I danced like a blind, obedient little puppet.

"Don't throw your life away, Kris," Stavenger pleaded. "You'll be destroying everything you've worked for. You'll be giving them the excuse they need to come back here and force us to obey their laws."

Humphries, she thought. Once I'm dead he'll be able to blame the whole thing on me. His lawyers will talk his way out of it. He'll walk away from this. From four murders. Five, counting me.

Cardenas carried the cup back to the sampling site and sealed its aluminum top to its rim. Once the top clicked into place she placed the cup in the disposal oven and closed its door. The inner walls of the oven fluoresced as its ultraviolet lamps bathed the cup.

Why should I die for Martin Humphries? she asked herself. Someone's got to stand up to him. Someone's got to tell the truth about this. No matter what it costs, I've got to face him, face all of them.

"Come on, Kris. Open the door."

They're watching me through the security camera, Cardenas knew. She went back to the computer and erased her message. One of the staff people can destroy the gobblers tomorrow, she told herself. They're safe enough in the oven for now.

Slowly she walked to the door, then stopped at the keypad on the wall next to it.

"Doug?" she called.

"I'm right here, Kris. Open the door, please."

"This is silly," she said, feeling stupid, "but I don't remember the sequence I used to reset the lock."

A mumble of voices on the other side of the door. Then Stavenger, sounding relieved, replied, "OK, Kris. Security's bringing an analyzer down anyway. We'll have it open in a few minutes."

"Doug?" she said again.

"Yes."

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"Thanks."

"*De nada*," he answered.

By the time they got the door unlocked, Cardenas was surprised at how calm she felt. She had looked death in the face and discovered that she was strong enough to go on living.

The passageway outside was crammed with men and women in security coveralls, half a dozen of her own nanotech people, several medics in white, and Doug Stavenger.

"Are you all right?" Stavenger asked worriedly.

Cardenas felt herself smile a little. "I am now," she said.

DEATH

"C'mon, boss, wake up!"

Pancho's voice, muffled, distant. Dan's eyes were gummy, bleary; it took an effort to open them. He tried to wipe them but his hands were still buried in the loose rubble of the asteroid.

"Dan! Wake up!"

He heard the urgency in her voice.

"Yeah. OK . . ." His stomach heaved.

"Radiation level's down almost to normal," Pancho said. "You OK?"

"Sure," he lied. He felt too weak to move, too tired to care.

"Time to get outta here." She was scrabbling, clawing through the gravelly dirt. Dan wanted to help her but he could barely move his arms. All he wanted to do was sleep. Then his guts suddenly lurched and a wave of nausea swept over him.

"We're up, in the open." Amanda's voice came through his helmet speaker.

"I'm gonna need some help here," Pancho replied. "Dan's in a bad way."

Dan was concentrating on not vomiting. Get me to a toilet, he begged silently. I don't want to let loose inside the suit. Even in the depth of his misery, though, somewhere in the back of his mind he laughed bitterly at himself. It all boils down to this, he thought. Everything you've done in your life doesn't amount to a teaspoon of applesauce. All that's really important is not upchucking or losing control of your bowels.

He sensed somebody digging frantically above him, and then strong arms lifting him, dragging him free of the rubble-filled tunnel. Fuchs. He overdid it, and the two of them went tumbling completely off the asteroid, spiralling crazily in space. Dan saw *Starpower 1* slide past his field of view and then an unstoppable surge of bile rose into his throat and he vomited, spattering his stomach's contents noisomely all over his fishbowl helmet. The stench was overpowering. He groaned and retched again.

"Hang in there, boss," Pancho said. "I gotcha."

Dan thought he heard someone else retching, too. Nothing like the sound of vomiting to make you upchuck, too. I could get the whole Vienna Boys Choir tossing their cookies this way.

He wavered in and out of consciousness, thinking, That's the way they get you. They make you so miserable that you'll be glad to die. He squeezed his eyes shut and tried not to breathe. He desperately wanted to wipe his face but inside the suit and helmet it was impossible.

"OK, the lock's cycling," he heard Pancho say.

"Bring him inside." Amanda's voice.

"Take him to his own bunk."

"Yes. Careful now."

He didn't dare open his eyes. At one point he heard Pancho say, "You get him out of his suit. I gotta see how much damage the storm did to the ship's systems."

After a while he felt something cool and soothing wiping his face. Opening his eyes at last Dan saw a blurred image of Amanda bending over him, with Fuchs beside her. They both looked worried, grim.

"How do you feel?" Amanda asked.

"Lousy," he croaked.

Fuchs said, "We are under way. Pancho is accelerating to one-third g."

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"The ship's OK?"

"Some of the sensors were damaged by the radiation," Fuchs said. "And the communications equipment, too. But the fusion powerplant is functioning properly."

"The nanobugs didn't get to the MHD generator's superconductor?" Dan asked. It took most of his strength to get the words out.

"No, they seem perfectly in order," Fuchs answered. Then he added, "Thank god."

We're on our way home, Dan thought. He closed his eyes. On our way home.

"Until you get him here where we can give him proper medical treatment," Selene's chief radiation therapist was saying, "there's nothing you can do for him beyond the chelation pills and antioxidants you're already giving him."

Pancho watched the medic's unhappy image as she sat disconsolately in the command pilot's chair. It had taken more than an hour to contact Selene. *Starpower I*'s high-gain antenna had been knocked out by radiation damage and she'd had to use the backup laser comm system. Otherwise the ship was running OK, some radiation damage here and there; nothing vital. The nanobugs hadn't gotten to the superconducting coil of the MHD generator, thank whatever gods there be.

But Dan was in a bad way, and the sad-assed medics at Selene couldn't do any more for him than a bunch of witch doctors. Bring him in as fast as you can. Well, sure! That's what I'm doin'. But will it be fast enough?

And Elly was dead. Just before they had abandoned the ship, she had left the snake in her box and put the box in the refrigerator, knowing the cold would put Elly into a torpor, hoping that the fridge would provide enough shielding to save the krait. I should've carried her inside my suit, Pancho berated herself. Even if she bit me, I should've brought her with me. The radiation had killed the krait, along with the one remaining mouse.

Her thoughts returned to Dan. He's got it bad. We all took a dose, we'll all need medical attention once we get back to Selene. The chelation pills are helping, but Dan might not make it. He looks half-dead already.

Amanda came into the bridge and slipped into the right-hand seat.

"How is he?" Pancho asked.

"We cleaned him up and he's sleeping now." She made a strange face. "His hair is coming out. In clumps."

Pancho fought down the urge to go back to Dan's compartment. Nothing you can do there, she told herself.

She asked Amanda, "How's Lars?"

"He seems to be fine."

"Did he take the pills?"

"Yes, of course. He's working on the high-gain antenna."

"That circuitry's supposed t'be hardened against radiation," Pancho said angrily. "We oughtta sue the manufacturer when we get back."

"Oh, Pancho, it was exposed to such a high level of radiation. That was an intense storm."

She nodded, but said, "Yeah, but still that comm gear has gotta work right."

"You need a rest," Amanda said.

"We all do."

"I'll take the conn. Go back and catch some sleep."

"Maybe you're right."

"Do it, Pancho."

She looked at Amanda for a brief moment, then made up her mind and slowly got to her feet, surprised at how stiff she felt. "If I'm not back in two hours, wake me up."

Amanda nodded.

"I mean it, Mandy. Two hours."

"Yes. I will."

Satisfied, Pancho made her way back through the wardroom. She hesitated at the door to her privacy compartment, then went a further few steps to Dan's door.

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She slid it open a crack. Dan was still sleeping, lying on the bunk, his body sheened with perspiration, the shorts and tee-shirt they had put on him stained by his sweat. His scalp was dotted with bald spots where tufts of hair had come out. God, he's in a bad way, she said to herself.

He opened his eyes and focused on her.

"Hi, kid," he breathed.

"How're you feelin', boss?"

"Not good."

"Anything I can bring you? I could fix some broth or somethin'."

"I'd just chuck it all over myself," he said.

"We'll be in Selene in another day and a half. Just rest yourself and we'll get the medics—"

"Did you send my last will and testament to them?" Dan asked.

Pancho shook her head. "Havin' troubles with the main antenna. Lars is workin' on it."

"How's the laser?"

"The backup? It's OK. We're usin' it to—"

"Send my will," Dan said.

"We don't hafta do that. You're gonna be fine."

"Send it," he insisted. He tried to raise himself on one elbow and failed. "Send it," he whispered.

"You sure you wanta leave everything to me?"

"Will you fight Humphries?"

She nodded solemnly. "Yep. That's a promise, boss."

"Good." He smiled weakly. "Send it. Now."

With a reluctant sigh, Pancho said, "OK, if that's what you want."

"That's what I want," he whispered. "And put in our claim to Haven, too."

She nearly smiled. That's more like Dan Randolph, she thought.

"One more day," said Fuchs.

He and Amanda sat side by side in the wardroom. Fuchs was picking halfheartedly at a breakfast of prepackaged eggs and soymeat. Amanda hardly looked at her cereal and fruit.

"One more day," she repeated glumly.

"You're not happy."

"Humphries is in Selene. It will start all over again once we get back."

"Not if you're married to me," Fuchs blurted.

She stared at him. He looked totally serious, almost solemn. But then his thin lips curved slowly into a hopeful smile.

Before she could think of anything to say, Fuchs went on, "I love you, Amanda. I'm not proposing to you merely to protect you from Humphries. I love you, and more than anything in the universe I want you to be my wife."

"But Lars, we've only known each other a few weeks. Not even that long."

"How long does it take?" he asked. "I've fallen hopelessly in love with you. It happened in an instant."

She felt stunned. This steady, capable, thoughtful, intelligent man was looking at her expectantly, his whole life shining in his pale blue eyes. He loves me? Amanda wondered. We haven't even kissed and he believes he loves me? Do I love him?

Fuchs licked his lips nervously and asked, "I know I'm only a graduate student and my prospects aren't very wonderful, but could you—I mean to say, do you think . . ."

He seemed to run out of words. He simply sat there, gazing at her as if afraid to say anything more.

She thought swiftly, never taking her eyes from his. He's strong. He's steady. He's wanted to come on to me, I've felt that often enough. Yet he didn't. He never even touched me, never said a word until now. He's honorable.

It seemed like an eternity before she heard herself whisper, "Yes, Lars. I'll be happy to marry you."

You can learn to love him, Amanda told herself. You know you can trust him, you know he's gentle and sweet. He'll protect you from Humphries.

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Fuchs leaned toward her and slid a strong arm around her waist. Amanda closed her eyes and they kissed, softly, tenderly at first. But she felt him clutch her to him, felt real strength and passion in the lingering kiss. She wound her arms around his neck.

After several minutes they separated slightly. Amanda felt breathless.

Fuchs was beaming like a thousand lasers. "We've got to tell Pancho!" he exclaimed, jumping to his feet. "And Dan!"

Laughing, he took Amanda's arm as she rose to her feet. He let her duck through the hatch to the bridge, then followed right behind her.

"Pancho, Lars has asked me to marry him!"

Pancho turned halfway around in her command chair and grinned at them. "'Bout time," she said. "I was wonderin' when you two would figger it out."

"We've got to tell Dan!"

Pancho nodded, scanned the instrument panel and saw that the ship's systems were performing adequately, then got up and started back with them.

"We oughtta perform the ceremony right here, get you legally hitched before we get back to Selene," she said.

"Oh! Could you?"

"Is the captain of a spacecraft legally empowered to perform marriages?" Fuchs asked.

"Oughtta be," Pancho said, shrugging.

They reached Dan's compartment and softly slid the accordion door back. Dan was lying on his back, his eyes closed, a sweaty sheet covering the lower half of his body.

"He's sleeping," Amanda said.

Dan's eyes popped open. "How can a sick man sleep with all the racket you're making?" he said, barely above a whisper.

Amanda's hands flew to her face. Fuchs started to apologize.

Dan waved a feeble hand to silence him. "If you can establish a comm link, you can get somebody on Earth to perform the ceremony."

"Hey, that's right," Pancho said.

Licking his dry, cracked lips, Dan asked, "You want the Pope in Rome? I've got some connections." Looking at Amanda, he added, "How about the Archbishop of Canterbury?"

"One of the ministers in Selene will do," Amanda said softly.

"I get it," Dan said. "You're in a hurry."

Fuchs turned red.

"I want to give the bride away," Dan said.

"Sure. Fine," said Pancho. "I'll set up the comm link." She headed back toward the bridge.

It took longer to make the arrangements than to perform the ceremony, even with a twelve-minute lag between the ship and Selene. Amanda and Fuchs stood by Dan's bunk with Pancho behind them. They had no flowers, no wedding attire except the coveralls they'd been wearing. The minister appeared on the wall screen opposite Dan's bunk. He was the pastor of Selene's interfaith chapel, a Lutheran: an ascetically thin young German with hair so blond it looked nearly white. Amanda could see that he was in his office, not the chapel itself. That didn't matter, she told herself. He conducted the brief rite in English and with great dignity, despite the time lag between them.

"Do each of you take the other for your lawful spouse?" the young minister asked.

"I do," said Fuchs immediately.

"I do," Amanda said.

They stood there feeling foolish and fidgety for the six minutes it took their response to reach the minister and the six additional minutes it took his words to reach them.

At last he said, "Then I pronounce you husband and wife. Congratulations. You may kiss the bride."

Amanda turned to Fuchs and they embraced. Pancho thanked the minister and cut the electronic link. The wall screen went dark.

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They turned to Dan, lying in his bunk.

"He's fallen asleep," Amanda whispered. But she stared at Dan's sweat-stained tee-shirt. His chest didn't seem to be moving.

Fuchs leaned over the bunk and pressed two fingers against Dan's carotid artery.

"I don't feel a pulse," he said.

Pancho grabbed Dan's wrist. "No pulse," she agreed.

"He's dead?" Amanda asked, feeling tears welling up in her eyes.

Fuchs nodded solemnly.

LIFE

Pancho's heart was thumping, and not merely from the heavier gravity of Earth. The quarterly meeting of Astro Corporation's board of directors was about to begin. Would they follow Dan's wishes and vote her onto the board? And what if they do? What do I know about directing a big corporation? she asked herself.

Not much, she admitted. But if Dan thought I could do it, then I gotta at least give it my best shot.

She stared at the other directors as they milled around the sideboard of the luxurious meeting room, pouring drinks for themselves and picking out delicate little sandwiches and stuff. They all looked old, and dignified, and wicked rich. Most of the women wore dresses, by jeeps, or suits with skirts. Expensive clothes. Lots of jewelry, too. Pancho felt shabby in her best pantsuit and no adornments except for a bracelet and pendant earrings of lunar aluminum.

They were ignoring her. They clumped together in twos and threes, talking to each other in low voices, not whispers exactly, but little buzzing heads-together conversations. Nobody even looked her way, yet Pancho got the feeling that were all talking about her.

Not even the plump oriental woman in the bright red dress spoke to her. She must know what it's like to be an outsider, Pancho thought. But she's keeping her distance, just like all the others.

Martin Humphries strode into the board room, decked out in a sky-blue business suit. Pancho clenched her fists. If he's in mourning for Dan, he sure ain't showing it, she thought. None of them are.

Humphries nodded here and there, saying hello and making small talk as he made his way past the sideboard toward Pancho. He glanced once out the long window above the sideboard and seemed almost to wince at the view of the sea out there. Then he turned and came toward Pancho. Stopping a meter or so in front of her, Humphries looked Pancho up and down, the expression on his face pretty close to a sneer.

"Do you honestly think we're going to allow a roughneck greasemonkey to have a seat on this board?"

Suppressing an urge to punch him out, Pancho said tightly, "We'll see purty soon, won't we?"

"We certainly will."

He was wearing his lifts, Pancho saw; still, Humphries was several centimeters shorter than she.

"What puzzles me," she said, looking down into his ice-gray eyes, "is how they can allow a convicted murderer t' stay on the board."

"I wasn't convicted of murder!" Humphries snapped, keeping his voice low.

Pancho made a small shrug. "They found you guilty of causin' Dan Randolph's death, didn't they?"

"I pleaded guilty to involuntary manslaughter. That was the deal my lawyers set up for me."

"Selene's court was way too easy on you. I would've hanged you. And not by the neck, either."

"They made me divest my holdings in Starpower!" he snarled. "Made me turn over my one-third to them!"

"And Astro," Pancho corrected. "You can still make money off Dan's dead body outta the profits Astro's gonna be pullin' in."

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"And they exiled me! Threw me out of Selene. Forbid me from returning for twenty years." He glanced over his shoulder at the view of the sea through the long sweeping window like a man looking back at something chasing him.

"You got off light," said Pancho. "Dr. Cardenas got a life sentence. She'll never be allowed to work in her own nanolab again."

"She was just as responsible for his death as I was. And so are you, for that matter."

"Me?"

"You were the captain of the vessel. You could have turned back once you realized the radiation shield was failing."

"Thanks to you."

Humphries smirked at her. "If Randolph had brought a proper medical man aboard, if he hadn't taken the ship before the IAA approved the flight—"

"That's right," Pancho growled, "blame the victim for the crime."

"You didn't even freeze him once he died. You didn't even try to."

"Wouldn't have done any good," Pancho said. "We couldn't've got his core temperature down quick enough."

They had thought about it, she and Mandy and Fuchs. They had even considered putting Dan's body into a spacesuit and dunking him into one of the fuel tanks. But a quick calculation showed the cryogenic fuel would be used up by the time they reached the Moon and Dan's body would thaw before they could transfer him to a proper dewar.

Humphries smiled slyly. "Or maybe you *wanted* him dead, so you could inherit from him?"

Pancho had her right fist cocked before she realized it. Humphries threw his hands up and scuttled several steps back from her. Everything stopped. The board room went absolutely quiet. All faces turned toward them.

With a deep, deliberate breath, Pancho put her hand down. Humphries straightened up, looking sheepish. The other directors turned back to their own conversations, trying to pretend that nothing had happened.

Scowling angrily, Humphries walked away from her. Pancho saw that most of the directors moved out of his way as he approached the sideboard. As if they didn't want to be close enough to touch him or even have him breathe on them.

"I think we'd better start the meeting," said a petite red-haired woman in a forest green skirted suit.

The directors went to the long polished table in the middle of the room and began to take their chairs. Pancho watched uncertainly for a moment, then saw that two chairs were unoccupied: one at the head of the table and another at its foot. Remembering her childhood Bible classes, she took the lowest chair. The redhead sat to the right of the empty chair at the table's head; Humphries sat opposite her, his back to the window.

Everyone looked around, as if wondering what to do next. The redhead slowly got to her feet.

"For those of you who don't know me," she said, looking down the table toward Pancho, "my name is Harriet O'Banian. As vice-chair for the board, I guess I'll have to run this meeting until a new chairperson is elected."

They all nodded. Pancho saw that a small display screen was built into the gleaming surface of the table in front of each place. It showed an abbreviated agenda.

"I'm going to dispense with the usual formalities," O'Banian said, "and proceed directly to—"

"May I interrupt?" Humphries asked, holding up his hand like a schoolboy.

O'Banian murmured, "Of course."

Rising to his feet, Humphries said earnestly, "I wasn't able to attend the emergency meeting of the board that was called when news of Dan Randolph's unfortunate death was revealed."

Unfortunate? Pancho snarled inwardly.

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"You all know that his death was partially my own fault. I played too rough, and I've seen the consequences. Please believe me, I never wanted to have Dan die."

The hell you didn't, Pancho said to herself. Looking along the table, though, she was shocked at the sympathetic expressions on many of the directors' faces.

"My real crime," Humphries went on, "was wanting to run Astro Corporation. And I let that ambition override my common sense. I saw Dan driving this fine organization into bankruptcy, and I knew that I could do better."

He stopped, hung his head for a moment. Pancho thought, The sumbitch should've been an actor.

"I'm truly sorry that Dan is dead. I feel a great weight of responsibility for it, even though that is not what I intended. I'll pay the price for my mistake for the rest of my life."

Pancho could barely keep herself from throwing something at him. But the other directors seemed calm, accepting.

Humphries wasn't through. "I know we can pull Astro through its current crisis. Despite Dan's unfortunate death, the mission to the Asteroid Belt was actually a success. Starpower, Ltd., now has rights to two asteroids that are worth several trillion international dollars on today's commodities markets. And Astro, of course, owns one-third of Starpower."

"One half," Pancho snapped.

Humphries stared at her for a long, speechless moment. "One half," he admitted at last. "That's right. Astro now owns half of Starpower."

"And Selene owns the other half," said Pancho.

Humphries bristled. Pancho grinned at him, thinking, I hope you choke on the money you'll be makin'.

Hattie O'Banian broke the tension-filled silence. "Thank you, Mr. Humphries. At this time, before we go on to the regular agenda, I would like to welcome Ms. Priscilla Lane to the board."

Pancho watched Humphries raise an eyebrow. Immediately, the oriental woman, sitting across the table from him, said, "Ms. Lane hasn't yet been elected to the board."

"I'm sure we can do that by acclamation," O'Banian said. "After all, Dan specifically—"

"It's customary to vote on a new member," said a florid-faced man with a full gray beard sitting a few chairs down from Humphries.

"After all, a position on the board isn't hereditary," the florid man grumbled. He reminded Pancho of Santa Claus, except that he was nowhere near being jolly. "You can't inherit board membership just because a dying man willed it to you."

Pancho understood the implication. Cripes, they think I was sleepin' with Dan and that's why he named me to the board.

O'Banian looked displeased. "Very well, then. In that case, I believe we should allow Ms. Lane to say a few words about herself."

All faces turned toward Pancho. Thinking furiously, she got slowly to her feet.

In her mind she heard Dan telling her, *My personnel people think you're a flake, Pancho. The rap on you is that you're not serious.* She knew that each member of the board had seen her personnel file. OK, Pancho, she said to herself, time to grow up and start bein' serious. You're in the big leagues now. You gotta show them your best.

She took a deep breath, then started, "I was just as surprised as any of you when Dan Randolph said he wanted me to take his place on this board. I'm an engineer and pilot, not a banker or a lawyer. But Dan said the board needed some fresh blood, and he picked me. So here I am."

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Surveying the men and women watching her, Pancho went on, "I think I know why Dan wanted me here—and it wasn't for my good looks, either."

A few chuckles. O'Banian smiled broadly.

"With all due respect to you, I think this board could use somebody who has some practical experience in Astro's activities. Dan sure did, but I don't think any of you have been involved in the company's actual operations. I've been flyin' Astro spacecraft for nearly seven years now. I've been out to the Belt and back. That's where our best chance of makin' real profits lies: out in the Belt. I know what it takes to get the job done. I think I can help this board to make the right decisions as we start to tap the resources of all those asteroids. Thank you."

She sat down. No one applauded. Humphries gave her a hard stare, then swept his eyes along the table, trying to fathom the opinions of the other directors.

"Oh, one more thing," Pancho said, without getting up from her chair. "If you do elect me to the board, I intend to vote for Ms. O'Banian as the new chairman."

Now Humphries scowled openly.

O'Banian said, "Very well. Let's vote, shall we? All in favor of Ms. Lane, raise your hands."

Two hours later, as the meeting broke up, Humphries accosted Pancho.

"Well, now you're a board member," he said. "By the margin of two votes."

"And Ms. O'Banian is the chairman of the board."

Humphries scoffed, "Do you think that's going to stop me from taking control of Astro?"

"It won't stop you from tryin', I know that."

"I'll get Astro," he said firmly. "And Starpower, too, eventually."

"Maybe," said Pancho. "And maybe not."

He laughed at her.

"Lissen, Humpy," Pancho growled. "I don't give a shit how your lawyers wiggled you out of it, you killed Dan Randolph. I'm gonna make sure that he haunts you for the rest of your natural days."

"I don't believe in ghosts," said Humphries.

Now Pancho laughed. "You will, Humpy. You surely will." □

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THE REFERENCE LIBRARY Tom Easton

Return to the Whorl, Gene Wolfe, TOR, $25.95, 412 pp. (ISBN: 0-312-87314-X).

The Graveyard Game, Kage Baker, Harcourt, $24, 298 pp. (ISBN: 0-15-100449-8).

The Cassandra Complex, Brian Stableford, TOR, $23.95, 319 pp. (ISBN: 0-312-87773-0).

Limit of Vision, Linda Nagata, TOR, $24.95, 349 pp. (ISBN: 0-312-87688-2).

K-PAX, Gene Brewer, St. Martin's, $6.50, 250 pp. (ISBN: 0-312-97702-6).

Have Starship, Will Travel, Ramona Louise Wheeler, Wildside, $14.95, 187 pp. (ISBN: 1-58715-280-0).

Starship for Hire, Ramona Louise Wheeler, Wildside, $14.95, 191 pp. (ISBN: 1-58715-284-3).

Mike Resnick: An Annotated Bibliography and Guide to His Work, Fiona Kelleghan, Farthest Star Science Fiction (distr. by Midpoint Trade Books, 27 West 20th Street, New York, NY 10011, 212-727-0190), $20, 480 pp. (ISBN: 1-57090-109-0).

In Space No One Can Hear You Laugh, Mike Resnick, Farthest Star Science Fiction (distr. by Midpoint Trade Books, 27 West 20th Street, New York, NY 10011, 212-727-0190), $16.95, 320 pp. (ISBN: 1-57090-106-6).

Code and Other Laws of Cyberspace, Lawrence Lessig, Basic Books, $16 (pb), 297 pp. (ISBN: 0-465-03913-8).

Frank Kelly Freas: As He Sees It, Frank Kelly Freas and Laura Brodian Freas, Paper Tiger (Sterling Publ. Co., 387 Park Avenue South, New York, NY 10016-8810), $29.95, 112 pp. (ISBN: 1-85585-848-7).

Mass: The Art of John Harris, Ron Tiner, Paper Tiger (Sterling Publ. Co., 387 Park Avenue South, New York, NY 10016-8810), $29.95, 112 pp. (ISBN: 1-85585-831-2).

It was over twenty years ago that Gene Wolfe began the singular future history that has so far extended through the multivolume Books of the New Sun, Long Sun, and Short Sun. The tale began in the distant, distant future, when civilizations are recorded in rock strata the way dinosaurs are today, and Earth (or Urth) is dominated by the sprawling, decaying city of Nessus. When I reviewed the final volume of the first major installment, *The Urth of the New Sun*, in January 1988, I said that Wolfe's overall point was that throughout our lives we make and remake ourselves, though we may first have to travel far. This was what Severian had done, beginning with *The Shadow of the Torturer* (reviewed November 1980). The adventures of Silk in the Book of the Long Sun—that sun being the light source for the "whorl," a hollowed asteroid en route to a new world, dominated by the uploaded minds of its builders, who claim to be gods—fit the same theme, though Silk was hardly done when it came time to send the whorl's inhabitants to Blue and Green, the planets of the Short Sun.

The Book of that Short Sun—*On Blue's Waters* (reviewed March 2000), *In Green's Jungles* (reviewed November

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2000), and now **Return to the Whorl**—followed the adventures of Horn, once a young associate of Silk's. He had come to Blue and built a life. But political chaos in the city of New Viron had prompted the city's elders to decide they needed a neutral, esteemed leader to achieve the peace and prosperity they craved. They drafted Horn to return to the Whorl, find Silk, and bring him back. And off he went, to meet the natives of Blue, get sidetracked to Green, a hothouse world infested by the bloodsucking, protean inhumi who come to resemble their victims—both in form and character—and die there.

Yet his tale did not end at that point. Somehow, his spirit was transported back to the Whorl and inserted into another's head. When he eventually returned to Blue, he was no longer recognized by people who knew the old Horn—including his own son Hide. And he was often mistaken for Silk. He was even credited with a wisdom and compassion quite worthy of Silk and drafted to rule the land of Gaon instead of New Viron.

Wolfe is a master of indirection. He tells a tale that fascinates and enchants even though it is hardly linear. He skips, he leaves out, he returns, and he skips again. *Return to the Whorl* goes back to fill in gaps, tie up loose ends, answer leftover questions, insert an astral visit to the Whorl's source (Nessus, of course), reveal why Blue's natives snuck a few inhumi aboard the Whorl, and in due time bring Horn—if that is who he is—back to New Viron and his wife and family.

Consonant with Wolfe's old theme, Horn or Silk or both has indeed been made and remade, and the theme adds a chord in the thought that transformation reveals truth. Horn (or Silk or both) has traveled far—and he is not yet done. With old friends and new, he sets forth from the last page upon another journey. With luck, Wolfe will bless us with still more of the tale.

* * *

Kage Baker has earned praise for her tales of the Company, a future-based outfit that "recruits" throughout time, turns its new troops into immortal cyborgs, and sends them out to fill in the blank spots of history, collect treasures before they are lost, and defend the Company's interests. One of those recruits was the Botanist Mendoza, who fell in love with a mortal in sixteenth-century Spain and watched him burn at the stake. In 1862, she encountered his lookalike, one Edward Alton Bell-Fairfax, in California and promptly vanished. In **The Graveyard Game**, Baker focuses on Mendoza's recruiter, Facilitator Joseph, and her friend, Literature Specialist Lewis. Both would like to know where she went, and why, but they know better than to be too obvious about it, for the Company can hear every word they say and is quite capable of reprogramming them.

It soon becomes clear that Mendoza is by no means the first or only cyborg to vanish. It is dangerous to know too much, to stumble on secrets, to display independence, or to show unusual talents. There are caverns, known in the records only as numbered sites, full of cyborgs in suspended animation. And as an obsessed Lewis researches Mendoza's lover—an illegitimate child, sponsored to a private school headed by a Company elder, a promising Navy career ended by insubordination, hints of secret-agentry, membership in exclusive clubs—he finds hints of depths beyond depths in the Company's history. There are factions, rebels, and secret enemies with potent weapons that can incapacitate the cyborgs.

What happened to Mendoza? Joseph does not know by the time this installment ends, but he's finally found the old-style cyborg—big and mean and programmed to kill killers—who recruited him ages ago, and now he's ready to pull out all the stops to write the last act of the drama.

He doesn't have long. The Silence be-

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yond which the cyborgs cannot pass falls in 2355, and there's less than a century to go. But judging from *The Graveyard Game*, Baker's going to do a bang-up job. She has an enviable array of writerly gifts for plot, color, character, and action.

In the past few years, Brian Stableford has been publishing a very interesting future history predicated on the development of near-immortality. *Inherit the Earth* (reviewed here in February 1999) gave us an Earth saved from overpopulation by a sterility plague, artificial wombs, and nanotech "internal technology" to extend life and make reality as malleable as image. *Architects of Emortality* (reviewed in March 2000) showed a new generation arising, whose nanotech has been replaced by genetic changes. *The Fountains of Youth* (reviewed in October 2000) looked at the aftermath.

Now he gives us **The Cassandra Complex**, set before any of the above, just a few years from now. Population is booming, a war of plagues such as "hyperflu" is looming, the prophets of disaster are uniformly ignored and are being driven mad by frustration, and a few researchers are doing some interesting genetic work with mice. Meet Dr. Lisa Friemann. She worked with those researchers as a student (one—Morgan Miller—was even her lover for a time) before she went into forensics work. Now she is old, though. Her young boss in the police department wants her out. And suddenly half the city is blacked out, someone opens her door despite her high-tech locks, and there's a gun in her face. They want her computer disks, apparently because they think Miller left a copy of certain secret data with her. As soon as they have the disks, they're gone, though not before spray-painting "Traitor" on her door.

It doesn't take long for Lisa to discover that Miller has been kidnapped, his current lover is missing too, and the mysterious someones torched the mouse lab, destroying, among other things, the famous "Mouseworld" project, an exercise in adaptation to overpopulation. Soon the cops are being bumped to one side by the Ministry of Defense, but they draft Lisa and keep her in the center of things for her familiarity with the people. This pays off, for there are clues to be seen; quite intriguingly, they point toward a group of extreme feminists.

What's going on? Cassandra could see the future but no one believed her; she was dismissed as mad. She is, for Stableford, an emblem of futility and a comment on the way people today refuse to see looming problems such as overpopulation. Perhaps, he says at the close, she "could have been cheerful if she had only been convinced that when all the mistakes have been made, honest endeavor and natural selection will see to it that we're bound to get it right in the end."

That, of course, is where the other three books lead (not forgetting that natural selection works by culling). This one defines the problem to which the plague that preceded *Inherit the Earth* was an answer and shows us the embryos that eventually gave rise to emortality. You will find it interesting and absorbing.

When I reviewed Linda Nagata's *Vast* in May 1999, I said that her nanotechnology had become a kind of biology, with people and their machines blending and blurring. Like Stableford, she has now dropped back in the history of nanotechnology to explore its roots; unlike Stableford, she is writing no prequel.

The novel in question is **Limit of Vision**. It begins as Virgil and Panwar, a pair of researchers, await a third, Gabrielle, who will present their work on LOVs (named because they are at the limit of vision, just big enough to see with the naked eye). LOVs are artificial organisms engineered from human

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nerve cells; they are safely relegated to vats on an orbiting satellite, for they and their kind have been banned from Earth's surface. However, the three researchers have implanted LOVs in the skin of their foreheads, where they could send tendrils into their brains to enhance mood and focus (useful for researchers!); the LOVs talk to each other with beams of blue-green light.

Gabrielle never shows, for she is dead in her lab. Why? Virgil and Panwar think they know—she got lost in a communicative trance, talking to the LOVs in orbit—but they can't say without revealing the trio's heinous breach of regulations. And when Virgil tries to remove the LOVs from Gabrielle's forehead, he is caught. Soon Panwar is dead, Virgil is on the run, and the orbiting LOVs are revealing frightening powers as they uncouple their module from the satellite and head for the ground.

Meanwhile, Ela Suvanatat is struggling desperately to maintain a career as a free-lance journalist in Vietnam. She is on the scene when the LOV module hits atmosphere and breaks up, and when the incandescent pieces strike the sea, she is the first on the scene. She wants a scoop. What she finds is surviving LOVs, and now she too is being hunted by the international regulators.

Needless to say, things develop rapidly from that point. Virgil arrives, the LOVs spread and evolve and display awesome potential, and the regulators play games that raise the question of whether the LOVs or they are more to be feared.

Once more, Nagata proves she can be trusted for a grand read.

Gene Brewer's **K-PAX** has just been reissued in paperback with "SOON TO BE A MAJOR MOTION PICTURE" blazoned across the cover and a sample of the sequel tucked into the back of the book.

What's *K-PAX*? Well, it's hardly a strikingly new idea. The centerpiece is a gentle, amiable psychiatric patient who claims to be a space alien named prot (rhymes with goat). As we see every time this chestnut surfaces, the alien has some very jaundiced opinions on the way we do things here, and he definitely has a busload of better ideas. He also knows things that no mere human could possibly know. So maybe . . .

Naturally enough, his shrink (Doc Brewer himself) is interested in tracking down this amnesic loony. In due time, he and a friendly journalist succeed. So prot is just a human with an extra personality, right? But he still knows too much, and he has some strange talents as well, including the ability to ride light beams for visits to Greenland and elsewhere. He's also having an astonishingly beneficial effect on the loonies on the wards with him. So maybe . . .

You get the idea. Brewer writes very smoothly, prot is a very sympathetic character, and the situation is sweet and charming enough to make a movie that will surely appeal to many.

And the sequel? An excerpt isn't much to go on, but I did conclude that Brewer should have stopped before he started it.

You met Ramona Louise Wheeler in these pages through four of her Ray & Rokey stories, concerning the adventures of a tramp starship pilot who loves to fly but hates planets, and his alien sidekick, a distinguished scholar who left home and family for good and sufficient reasons. Those four stories were not the only ones in Ramona's inventory, however, and writing is not her only talent.

Have Starship, Will Travel begins with "Rogue Diamond," in which Ray and Rokey meet for the first time, and continues through "The Flavor of Fire," the first of the published stories, and three more. **Starship for Hire** offers another five tales.

The flavor is traditional. Wheeler writes that she was heavily influenced

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by Robert A. Heinlein and—at the same time—the old TV series, "Have Gun, Will Travel." She's doing space opera in that episodic vein tapped by Laurence Janifer, Poul Anderson, Harry Harrison, Keith Laumer, and many more. She's having fun, and thanks to her characters, she's doing a very entertaining job of it. If you enjoyed the stories you saw here, you will surely enjoy the rest as well.

You should also watch for her third book, **Nanosity**. I don't have a review copy of that one, but it is due out about the same time as the others. Its theme is nanotechnology, and its stories include "Upgrade," which appeared here in 1999.

As for that other talent I mentioned—Wheeler did the cover art for all three books.

In **Mike Resnick: An Annotated Bibliography and Guide to His Work**, Fiona Kelleghan assures us that Mike Resnick is prolific and versatile and possessed of a rollicking wit, and after a brief summary of his career she documents his *oeuvre* with almost 300 pages of bibliographic details, another 20 of honors and awards, and 50 more of related material. Her book is thorough and impressive testimony to Mike's industriousness, popularity, and significance to the field of SF . . . and he's not done yet!

And if you don't believe that Mike has a rollicking wit, nothing can bring you around faster than **In Space No One Can Hear You Laugh**. This is a collection of some three dozen short pieces—the Lone Ranger gets a trim from a Jewish Tonto, Santa visits a private eye, Mike interviews God Himself—every one of which is sure to provoke at least a smile while a few will knock you right out of your chair.

I recently picked up a copy of legal scholar Lawrence Lessig's **Code and Other Laws of Cyberspace**. The book—published in 1999—isn't brand new, but I think it's worth some attention. This is so because its theme is the changing nature of the online world, whose roots are the sort of anarchic free speech the campuses of the sixties were renowned for, but whose future is just as button-down as most of those old-time hippies became in due time.

Perhaps most of you are nodding your heads, thinking of porn sites and bomb-making manuals and Heaven's Gate cults, and muttering something like, "Yup! There oughta be a law to keep those things out of decent sight!" You're not alone, and legislators keep trying to Do Something, albeit without much success (that annoying Bill of Rights, you understand).

The greater push toward button-downdom, says Lessig, is commercial. As more and more commerce becomes e-commerce, there is more and more concern over security. This leads to encryption and identity-checking systems that go well beyond simple passwords. The result is the ability to monitor online behavior and therefore to regulate it. If government chooses to encourage it—less by legislation than by offering incentives such as a small discount on your taxes if you file using an approved "digital signature" system—it will not be long at all before that Olde Tyme Anarchy is as dead as the sixties.

Lessig is arguing neither for nor against this. Rather, he is saying that it is nonsense to insist that the Net is free by nature. Since it is entirely built by human hands, it has no "nature" beyond what we give it in the form of "code" (software and hardware). It can therefore be a realm of freedom or of oppression, and it is up to us to understand how it can change, what may impel the change, and what the consequences may be. Then it is up to us to choose the Net we desire in much the way our Founding Fathers chose a government and a nation. If we fail to understand and to choose, we may well not like what we get.

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Unfortunately, he is not hopeful. "My argument," he writes on page 212, "is that [we are not capable of that choice]. We have so completely passed off questions of principle to the judicial branch, and so completely corrupted our legislative process with the backhand of handouts, that we confront this moment of extraordinary importance incapable of making any useful decisions. We have been caught off-guard, drunk on the political indulgence of an era, and the most we may be able to do is stay on our feet until we have time to sober up."

That is a sobering appraisal. It behooves us to listen to what he is saying.

Frank Kelly Freas has been one of the most distinctive artists of science fiction and fantasy for half a century, but you know that, for this magazine has benefited from his talents ever since the Campbell days. If you wish an overview of his work, full of sparkle and verve, you can hardly do better than to pick up a copy of **Frank Kelly Freas: As He Sees It**.

If you do, you will also get to see some nice portraits of Robert A. Heinlein, L. Sprague de Camp; John W. Campbell, Jr., and a few others.

In his own way, John Harris is also quite distinctive, for he shows a fondness for—in the words of Ron Tiner—"vast megalithic structures of incalculable mass [that] hang weightless, as though poised on the brink of some fateful occurrence of cosmic proportions." Portent instead of sparkle and verve, but that may make **Mass: The Art of John Harris** very much to your taste. ■

EDITORIAL Stanley Schmidt

TEMPORAL PROVINCIALISM

Continued from page 7

sult in entirely new stories, unrecognizably different from the originals. In the real 2001, we obviously do not have some of the space technology that was central to the original stories and was supposedly developed before the turn of the century. On the other hand, we do have computers everywhere, and a pervasive internet that would change a great deal of how the stories would actually play out—and was anticipated by virtually no one when I wrote the stories. The important things that the stories have to say are unaffected by the fact that the 2017 we actually get is not going to be the one I imagined in the mid-Seventies. It won't be any that I might imagine now, either. So the most sensible course seemed to be not to try an update that served no real purpose and couldn't really succeed, but to let the stories stand as they were, trusting my readers to make allowances for when they were written.

Science fiction readers are usually pretty good at that. People attracted to this field, I suspect, tend to have a special affinity for trying on other viewpoints, whether that of a different time or place, or an earlier vision of the future . But everybody needs to develop that ability. There are many people and cultures in this world that need to learn to get along, and that means learning to understand each other. Trying to make other cultures and periods "relevant" by distorting them to look like ours is at best a stopgap approximation to that. What we really need is better ways to make people understand that folks in other times and places may see things quite differently—but if you can learn to see things their way, you just may find that their actions make sense and deserve your empathy anyway. ■

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BRASS TACKS

Dear Mr. Schmidt:

Perhaps you are merely playing "devil's advocate" with your editorial in the March 2001 issue of *Analog*. For years I've been quite impressed with your magazine's attempts at getting people to look at the world from different perspectives. The fictional stories about what the world may be like in the future depending upon what we do in the next few decades have been very thought-provoking as well. And you have an extremely efficient printer advertising in your magazine every month (3mpub.com).

But I will take your editorial at face value. After all your years in the publishing business, you should know firsthand how the publishing industry (and the *music* publishing industry in particular) have cheated artists for over a century now. The Constitution granted Congress the power to provide for copyright and patent protection for very specific reasons: "To promote the progress of science and useful arts". Nowhere did it mention allowing publishers or manufacturers to become obscenely rich by cheating creators and customers, and then using their ill-gotten riches to further their abuses of power in other spheres of influence.

If Napster and others who will no doubt follow in their wake can shake up the system and help to change it, they will have performed a valuable service, indeed. Your defense of the status quo in the name of copyright violations and cutting into owners' income just doesn't make sense. The middlemen have been cheating both sides in most cases. Consumers have been overcharged for decades, and artists have not gotten their fair share. Elimination of middlemen is a must in the music and book publishing industries—and in many other industries as well. Unfortunately those middlemen have come to have a disproportionately large amount of power, thanks to the laws passed on their behalf by our wonderful legislators, ridiculous decisions rendered by our incompetent judges, and harassment of citizens by career bureaucrats. The internet had promise as a means of disseminating ideas—but it has been taken over by corporate America (AOL/Time Warner) and a deluge of pyramid schemes which promise to make everyone rich. We need more Napsters willing to go against the flow.

Thanks for listening, and keep up the good work. At least, I hope you'll keep up the good work of trying to make people *think*.

Robert L. Minteer
Bozeman, MT

First, you shouldn't always take editorials at face value. I've mentioned several times that I'm perfectly willing to expound a viewpoint I don't actually hold if I think it will start a good argument and, as you say, "make people think."

However, this was not one of those cases—though I had to reread my editorial to see if the one you read was actually the one I wrote. Evidently it wasn't. I did not, for example, "defend the status quo." My whole main point was that things are going to have to change—but Napster isn't the way, and I find your defense of it rather as-

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tonishing. Let me get this straight: since in the past some publishers have not dealt with artists as fairly as they should have, e.g. giving them too little of the proceeds from distribution of their work, it's an improvement to start distributing it with no *compensation to the creators, and without their consent?*

The mind boggles!

Dear Mr. Schmidt,

Having just read the March editorial, I find that you've failed to make full disclosure, and have misstated the case for the free exchange of information. The misstatement is that you failed to mention the critical difference between taking a copy of a piece of intellectual property and taking groceries from the local supermarket. When you take something from the supermarket, the supermarket has tangibly lost something. When you copy a piece of intellectual property, nothing tangible has been lost by either the owner or the creator of the original. The creator is asking for money even though they give up nothing in exchange. Practicing that in your local supermarket will probably get you the same place as trying to take groceries.

That you can give all your friends something you find useful or pleasurable without giving it up yourself—and do so at a cost so small as to be difficult to measure—is a fundamental change in the nature of the economy. It's similar to the introduction of electric power, allowing you to obtain work from a wall socket at a cost so much smaller than was previously possible as to be negligible. Or possibly the introduction of money, which made it possible to literally coin wealth.

Such changes tend to cause major disruptions in the world. As you say, you have to think about both the long and short-term consequences of your choices, and choose conscientiously. One choice is to recognize that we now have the ability to create wealth in the form of information as fast as we can move it over the internet, and to arrange things so everyone can have as much of this new-found wealth as they want. The other is to preserve the status quo, and use the technology to maintain an artificial scarcity of information—and in the process, probably lose many of the rights to information that we already have. Neither choice will be painless, but I'd prefer to make everyone wealthy if I can.

That said, copyright violation is still illegal, and I'm not advocating that anyone engage in illegal activity. It behooves everyone, on both sides of the issue, to be aware of the legislative activity, and to try to ensure that the laws are moving in the proper direction.

Oh yes—what you failed to disclose was that you receive at least part of your income from activities that depend on the status quo you're defending.

Mike Meyer

If you think the cost of electric power is negligible, try disconnecting your electric meter to avoid paying your bill and see how well that goes over!

Of course no analogy is perfect, but you've missed, or chosen to ignore, several of the key arguments in my essay. I hope you'll read it again and try harder to understand them. Or do you really think it's OK for other people to get rich by copying a creator's work without the creator sharing in that wealth?

As for my "not disclosing" that part of my income depends on copyright, I thought that was too obvious to mention. But I am not *"defending the status quo"!*

Dear Editor:

I read your editorial regarding Napster, copyright, and the rights of the artists to be compensated for their efforts. Let us leave aside the obvious point that most of the artists in music

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recording industry have long since been compensated for their creative efforts and, in fact, no longer even possess the copyrights for their works.

By one of those interesting confluence events, I read your editorial against the backdrop of the resolution of the injunctions against Napster, and my first exposure to the beast itself. I think what is missing in your discussion of the matter is the way in which the music is experienced.

The recording industry is taking the position that the consumers of Napster files are making permanent copies of the music. This is not what I have observed as a consumer of Napster files. For me, the experience is more like radio, consuming the music in an instant listening experience. While it is true that I do have the copies for a few days, these are not permanent files. Who in the consumer market has that much available memory to keep that stuff forever? And this is allegedly the same market as the consumers of CDs and tapes.

Remember when you first got your VCR and recorded everything? You probably don't do so much of that now. It's wasteful, with little return.

This Napster affair reminds me of the same problems between the radio and the music industries back in the 1930s. Then the clash was between ASCAP and the radio stations. It gave birth to Broadcast Music, Inc. (BMI) which promptly started licensing the artists ignored or forgotten by the Tin Pan Alley types: the blues, hillbilly music, Latin groups, and weird teenagers. And what are we listening to these days? See above. It will be interesting to see all the unintended results of the music industry yet again trying to squeeze a new technology.

George Inzer

The "obvious" point is frequently not true, and in the cases where it is, does not justify the conclusion. Artists with any business sense, and/or good agents, do not sign away all of their rights for flat fees—they sell specific rights on terms that include a percentage of proceeds.

You're undoubtedly right that some of the copies being made are not permanent (as you hint, I use a VCR mostly for "time-shifting" and zapping commercials), but many of them are—and those are a legitimate source of concern. Videotapes can be used over and over; CDs (in their present form) can't.

Dear Stan,

I just finished reading J. Brian Clarke's novelette, "Wet", in the March issue. The situation was that a group of damp-loving aliens wanted to colonize a small part of Earth, and manipulate the climate to suit themselves. Mention was made of previous climate control disasters that left the Sahara hotter and dryer. The aliens are eventually invited to live on the Queen Charlotte Islands, an admittedly wet piece of real estate.

What an unexploited opportunity! Why ever were they not given free rein to moisten the Sahara as much as they liked? How disappointing. Besides, Canadian native treaty rights would keep the aliens trying to negotiate their way down from orbit for years.

Steve Hansen Smythe

Wetting the Sahara might be a desirable solution from the standpoint of many humans, but I can't see it appealing to the visitors. Which kind of real estate would you rather have: one that requires a little modification to make it just right for you, or one that would require a huge amount?

To the editor and Dr. Cramer,

What a shame that Isaac Asimov is gone! Imagine what the author of "The Endochronic Properties of Resublimated Thiotimoline" could have done with this ("The Alternate View," March 2001)!

Morton W. Kahl

The author replies. . . .

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I was thinking of Isaac when I wrote the column. I read his "article" when I was a teenager, and at first I was completely taken in by it.

However, his "resublimated thiotimoline" did result in a violation of the causality law, while (surprisingly) laser pulses that emerge from a medium before they enter it do not.

John G. Cramer

Dear Mr. Schmidt,

Neither Eric Rosenfield nor you (Brass Tacks, *Analog*, March 2001) even mentioned the obvious solution to an accomplished writer fitting profanity into the story being written.

I say "obvious," even though neither of you mentioned it, because I have encountered it in innumerable stories over the years.

No author has ever written a story in the "native tongue" when it involves an alien planet. Nobody would be able to read it!

Stories have been written involving conversations between people from societies using a language different from that in which the story is written, or discussions between people who speak different languages. Some of these offend me because I am unfamiliar with the foreign language being used and I lose part of the story (and interest in the story) as a result.

Most accomplished authors do the reader the favor of translating the conversation into the language in which the story is written. Sometimes a reference is made to this fact (e.g., a story involving an electronic translating device), sometimes it is taken for granted that the reader understands the translation that has taken place.

The culture in which I grew up and currently live in considers "swears" to be a foreign language, to be used as necessary to communicate with those to whom this is a native tongue. When I read a story about people from a "swears" society, I appreciate the author's efforts to translate, just as I would if they were from Spanish, German, French, etc., societies. I know what has happened; I'm aware of what took place on the other side of the translation. And I'd rather read the translation than have to wade through the string upon string of *foreign words*.

Authors should write to their audience. If the author is writing for me to buy his story, he will translate! If the author is writing for the story to be purchased by a member of "swears" society, he should write in "swears"!

Neal H. Krape

An interesting suggestion, but not very realistic. You and your subculture may claim to consider profanity a "foreign language," but the fact is that it's a generally understood part of English, which I'm quite confident that even you understand. So no translation is necessary for comprehensibility, and your subculture is a small part of the total audience; so the suggestion that writers should "translate" for your benefit is not practical since they are also writing for a great many other people who don't share your view.

Dear Dr. Schmidt,

Although I have been reading *Analog* since before you were born, I have managed to avoid writing to the editor until now, and you can imagine that there were many temptations in all this time. Over the last several years your occasional editorials on English usage as regards the female sex have moved me to a bemused smile or a sad shake of the head, but the Special Feature by Walter G. Aiello in the March issue has finally stirred me enough to produce a reaction in writing.

I am not interested in defending the works on language by radical feminist philosophers, but would like to try to explain to you why women who simply have practical problems of earning a living have needed the changes in usage

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which you so deride.

I came into the world of chemistry a very long time ago, and attended my first meeting of the American Chemical Society in 1945. The sign that met me when I entered had a double arrow: the left-hand pointer said "chemists" and the right hand one said "ladies". As you can see, after all these years I remember the event. I assume even you will agree that the modern way of designating 'significant others' in conference material is an improvement

I suppose I should mention the obvious, which is that I would not even have had a job in the chemical industry at that time except that no young man was available for civilian hire. I stayed in industry and eventually became a manager. You cannot imagine the confusion my presence at meetings caused outside visitors, especially when I was not asked to bring in the coffee and take the minutes, but you cannot imagine the worse distress that was caused when someone had to send me a business letter. When writing to an unknown man, the salutation is obviously "Mr". Believe me, the invention of "Ms" took care of a most aggravating problem in business etiquette when women were added to the mix. Surely your business letter writing would be rather hindered if every salutation to Mr. Somebody had to read either mMr. or uMr. to specify the recipient's marriage status.

I could go on endlessly with other examples, but the important point is that when one is involved in dealing with other human beings on matters not involving social relations, sexual markers are not only irrelevant, they are counterproductive. I have therefore been much cheered by the changes in language which have taken place in my lifetime to level the nonsocial playing field.

If you would like to run a personal experiment in this area, may I suggest that you pull out E. E. Smith's Lensmen series and reread it. Watching his unconscious assumptions about the eternal bases of society's organizations is a salutary lesson. I always enjoy the lady librarians doing a search with needles for the mind-reading, galaxy-travelling hero. Even more instructive is to see Doc Smith grappling with a changing postwar sensibility so that he finally has to cook up a female lensman—although she is still unique of all her sex, and still manages to keeps her deep motherly persona.

To sum up, all that people like me are asking for is some practical adjustments to the language that will make our society function more efficiently. It is only a corollary benefit that the sensitivities of the minority group involved will also be soothed and that this might improve social relations in a remarkably difficult world.

Juliette M. Moran

Yes, your wishes are reasonable and some changes are genuinely desirable. Hardly anyone I know would deny that "Ms." Is a welcome addition to the language, and I wish English would *adopt a gender-unspecified third person pronoun (which, by the way, many other languages have, but I've never seen any evidence that it leads to a sexism-free society). However, Mr. Aiello's satire was not on perfectly reasonable concerns as yours, but on the unreasonable extremes to which some have attempted to carry them (which I would think might bother you, too, since unreasonable extremists tend to interfere with the credibility of those with more rational views). If the shoe doesn't fit, it wasn't meant for you!*

Dear Stanley,

A "well done" to Shane Tourtellotte and *Analog* for February's "Nanoweights". I have often thought SF tends to ignore sport, but it is an important facet of our culture. Shane demonstrated there's plenty of opportunity for SF stories to cover the subject, and did so in a neat, concise little tale.

Roy Gray
Macclesfield, Cheshire, UK ■

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UPCOMING EVENTS Anthony Lewis

7–9 September 2001
COPPERCON 21 (Arizona SF conference) at Holiday Inn Sunspree, Scottsdale, AZ. Guest of Honor—Julian May, Artist Guest of Honor—Mark Roland, Music Guest—Heather Alexander. Registration—$35 until 26 August 2001, $40 at the door. Info—Coppercon 21, Box 62613, Phoenix, AZ 85082, phone—(602)973-2341, email—<leigh@casfs.org>, URL—<www.coppercon.org>

28–30 September 2001
ARCANA 31 (Twin Cities area SF conference) at Holiday Inn Express-Bandana Square, St. Paul, MN. Guest of Honor — Robert M. Price, Special Guest—Eleanor Arnason. Registration—tba (see web page). Info—Arcana 31, Box 8036, Lake Street Station, Minneapolis, MN 55408, phone—(612)721-5959, email—<eheideman@mpls.lib.mn.us>, URL— <http://pages.prodigy.net.rekal>

28–30 September 2001
CAPCLAVE 2001 (Washington, DC area SF conference) at Sheraton College Park Hotel, Beltsville, MD. Guest of Honor — Gardner N. Dozois, Ghost of Honor—Joe Mayhew. Registration—$30. Info—Capclave 2001, 4030 Eighth St., Arlington, VA 22204, URL—<www.wsfa.org/capc01>

28–30 September 2001
FOOLSCAP III (Washington state SF conference) at Southcenter Best Western, Tukwila, WA. Guests of Honor—Phil and Kaja Foglio. Registration—$41 until 21 September 2001, $45 at the door. Banquet—$20 in advance, $23 at the door. Info—Foolscap, Box 2461, Seattle, WA 98111-2461, phone—(206)301-9630, email—<scarlet@drizzle.com>, URL— <www.alexicom.net.foolscap/index.html>

1–4 November 2001
WORLD FANTASY CONVENTION 28 at Hotel Delta Centre-Ville, Montreal, Quebec. Guests of Honor—Fred Saberhagen, Joel Champetier, TM—Charles deLint. Registration—Attending: $125/C$175 until 30 June 2001, Supporting: $30/C$45 until 15 October 2001 (latest information at press time). Info—2001 WFC, c/o Bruce Farr, Box 7191, Chandler, AZ 85246-7191, (602)395-1945 email—<brucex.farr@intel.com> URL—< www.worldfantasy.org/wfc01.html>

29 August–2 September 2002
CONJOSE (60th World Science Fiction Convention) at Convention Center, et al., San Jose, CA. Guests of Honor—Vernor Vinge, David A. Cherry, Bjo & John Trimble, TM—Tad Williams. Registration—$140 until 10 July 2001, more thereafter. [These are the latest rates posted on the Internet as of the time this column went to press.] This is the SF universe's annual get-together. Professionals and readers from all over the world will be in attendance. Talks, panels, films, fancy dress competition—the works. Info—ConJose, Box 61363, Sunnyvale, CA 94088-1363. email—<info@conjose.org>, URL—<www.conjose.org>

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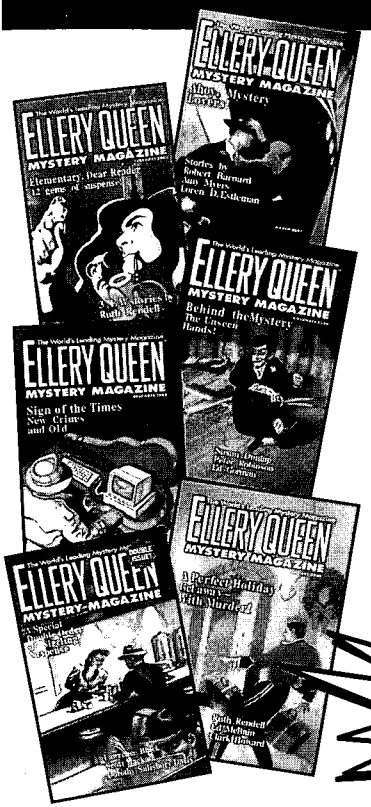

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